TEXTILE
MACHINE DRAWING

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& Sons, Ltd., Textile Engineers and
Ironfounders, Arbroath

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Textile Mathematics
In two parts

Textile Mechanics

Textile Machine Drawing

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PREFACE

The present work is the third of a series of elementary manuals dealing with the science subjects most closely related to the textile industry. It has been prepared to enable prospective textile students and others to become familiar with machine drawing, and thus to provide them with the knowledge necessary for the understanding, working or superintendence of textile mechanism.

The great advantages which accrue from a course of machine drawing cannot be overestimated, particularly when the student executes the drawings from dimensioned freehand sketches made by himself from actual machinery. The very work of drawing the various parts of a machine provides an insight which can only be equalled by an extended acquaintance with the machine and its functions. It is mainly for this reason that we constantly advocate this particular branch of study to textile students, to supplement and to precede, if possible, the courses which are considered to be more directly connected with the technological aspect of the textile industry.

T. WOODHOUSE.
A. BRAND.

January, 1921.

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TEXTILE MACHINE DRAWING

CHAPTER I

INTRODUCTORY

In the pursuit of any branch of technical work, the student does not proceed very far before he realizes the necessity for, and the advantage of, a knowledge of drawing. Many objects have to be described in some form or other, and in a certain number of cases it is possible to describe the object under consideration in a very few words. For example, one might take the shuttle-box spindle of a loom; it is a round rod, generally made from steel, and therefore simple in structure. If such a spindle were $\frac{9}{16}$ in. diameter, and 26 in. long (often written 2′ 2″ long), its shape, dimensions, and the material from which it is made might be stated concisely as under:

$\frac{9}{16}$″ diameter × 2′ 2″ long, bright steel.

But if one takes such a machine part as the sword of a loom—one of the heavy brackets which support the lay—no such simple description is possible. Any written description which could convey to the mind of the reader a complete knowledge of the shape and dimensions of a sword would be an intricate and complicated statement; so much so that it would require an exceptionally able mind to grasp the details, and visualize the part. In such a case, and there are many of similar difficulty, a representation of the part by means of a drawing or drawings, showing the correct and complete shape of the part, and upon which drawings the various dimensions are clearly marked, is absolutely necessary.

The occupant of any important industrial post is better fitted for his duties if he understands the making of drawings than he is when unacquainted with this work, although a knowledge of this branch is not absolutely essential. But there are few positions in which the occupants can afford to be unable to read and understand a drawing. To take a concrete case, one has only to think of the majority of students who attend textile classes (and other classes) throughout the country. Many of these — clerks, tenters, mill-machinery operators, &c.—are never called upon in the course of their daily work to produce a working drawing, but none of them can pick up a technical paper, or open a modern technical book, without finding the majority of the illustrations to be line drawings. If the readers are unable to understand these drawings, a large part of the authors' work loses much of its value, and in many cases the readers might as well leave the books or papers untouched.

It is obvious that the best way to learn to read drawings is to learn how they are made, and, more important still, to make them. Indeed, we are quite convinced, and have expressed the opinion for some considerable time, that no student should be allowed to take up the mechanical side of the study of spinning or weaving until he has had a year's training in mechanical drawing, and preferably in the textile department. A corresponding training in mathematics and mechanics would be of extreme advantage.

CHAPTER II

PENCILS, PAPER, INSTRUMENTS, ETC.

It is an old maxim which reads that "bad workmen blame their tools"; it is equally true that the student who provides himself with a good kit of tools has more chance of producing good work than he who, through any cause, is less well equipped. In no educational work is there more need for good tools than in the study and practice of mechanical drawing. It will generally be conceded—and always by teachers of the subject—that those who fail to make satisfactory progress after a reasonable time are nearly always badly equipped with the necessary instruments.

It is not to be inferred from the above remarks that an expensive and varied outfit of drawing-instruments is necessary; on the contrary, the smallest possible set of instruments necessary for the kind of work to be done should be acquired, but these should be of good quality. The choice of a case of instruments is almost invariably settled by the amount of money at hand, and no better advice can be offered to the beginner than that he should acquire as good a set of tools as he can afford.

It is not our intention to go deeply into the question of an outfit for a beginner, but the following paragraphs present a few facts concerning drawing-instruments, pencils, paper, &c., which we think are worthy of careful thought and study.

Pencils.—These are made of many shapes, and in many qualities; the beginner should provide himself with at least three grades, viz. H, HH or 2H, and HHH or 3H. The first is useful for writing notes on drawings; the second is that with which most of the drawing should be done; while the third and hardest should be kept for centre lines or for very fine detail work. It may be argued that these grades are too soft, since professional draughtsmen, in particular, usually have a weakness for very hard pencils up to 5H and 6H, but the beginner is well advised to start with the softer grades, and use them until he himself finds the necessity for the harder qualities.

A pencil for use in mechanical drawing should possess general and particular qualities; the lead should be easily sharpened, should be durable so as to retain its working point for a long time, and should be perfectly uniform in quality throughout; the wood should be of such a shape that the pencil is not liable to roll off the drawing-board, and the lead should be round for the sake of economy, as the pencil stumps may be stripped of their wood and used up in the compasses.

The wood should be straight grained, so that it may be readily and evenly removed by a pocket-knife.

Perhaps the most common shape is that indicated at A, fig. 1, which shows the well known hexagon form with a round lead. The flat sides tend to prevent the pencil from rolling off a sloping drawing-board, but this desideratum is perhaps better fulfilled by those of the somewhat elliptical section shown at B in the same figure, or those of the triangular section as at C, although the latter two are not extensively used.

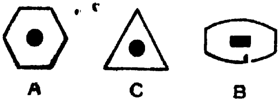

Fig. 1

The pencils with a section similar to B, fig. 1, usually have a lead of rectangular section, and this shape of lead lends itself more readily than do the others to the formation of the so-called flat chisel-point, which is most necessary for the continuous production of fine lines.

The chisel-point is illustrated at A, fig. 2; the wood should be cut to the shape indicated by means of a sharp knife, and the lead brought to the required form by the same instrument; better results are obtained by rubbing the lead on a 6-in. flat smooth file, and finishing off by a gentle rubbing over a piece of soft thick paper, such as blotting-paper. A strip of smooth tape emery-cloth or fine sand-paper may take the place of the file. This chisel-point is necessary for the drawing of all straight lines, the long edge of the flat lead

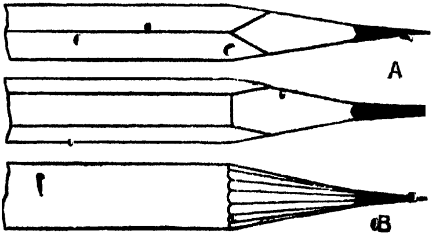

Fig. 2

being kept parallel to the edge of the T-square or set-square. At B, in fig. 2, is shown the ordinary conical point which is best suited for writing notes on drawings, and for the making of freehand sketches.

Rubber.—Care should be exercised in the selection of the rubber used for erasing faulty and unnecessary lines. The rubber should not be of the highly vulcanized, hard, or gritty nature common to most cheap qualities, as such rubber is sure to destroy the surface of the paper, and make it unfit to take ink or colour if these are to be used. For the sake of economy, the rubber should not be too soft, as many of the softer varieties possess poor erasing qualities and waste rapidly in use. A medium grade of fine vulcanized grey or green rubber will be found most generally useful, and part of it should be cut to a nice edge to enable it to enter small corners and between closely-set lines. Where part of a complicated drawing is to be removed, it is usually best to make a paper shield, i.e. a piece of paper with a hole cut in it to the shape of the part which has to be erased. Erasing shields of thin, highly-polished metal are sold for this express purpose.

For cleaning up drawings preparatory to lining-in, inking-in, or colouring, stale bread crumbs prove most useful, and are a good substitute for proprietary articles such as artgum.

Compasses, &c.—As previously mentioned, the student should provide himself with the best case of instruments he can afford. It is false economy to purchase cheap instruments, as they give no satisfaction in use, and do not last for any length of time. Durability is ensured by seeing that all joints are of the double-sector variety, while adaptability in use may be secured by seeing that the larger instruments are double-jointed, and that the points are needle-points, and not of the triangular variety, The double-sector gives increased wearing surface to the joints; the double knee-joints enable the user always to keep the points perpendicular to the surface of the paper; while the use of needle-points, in preference to the unsatisfactory triangular type, prevents the making of large holes in the paper when many circles or arcs have to be drawn from one centre.

A set of instruments which will be found suitable for the work detailed in succeeding chapters of this book comprises the following:—

1 pair of 4½-in. dividers.
1 pair of 3¾-in. or 4-in. pencil compasses with removable lead-holder.
1 lengthening-bar for the above.
1 inking-pen for the above.
1 4½-in. inking-pen.
1 pair of pencil spring-bow compasses.
1 pair of inking spring-bow compasses.
1 pair of spring-bow dividers.

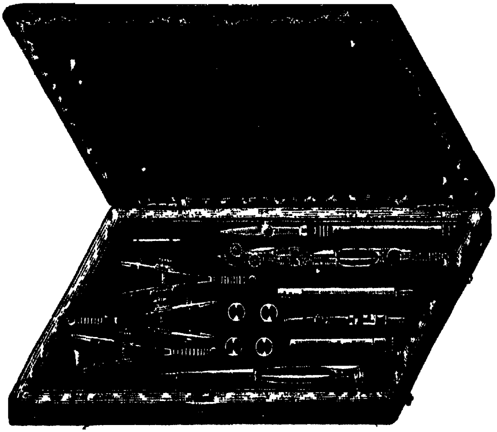

Fig. 3

There are many excellent sets of instruments on the market, some of which contain more instruments than are mentioned in the above list; others again contain fewer instruments, but a very suitable case is illustrated in fig. 3, and it might be advisable to note that the case is best when strongly and substantially made of wood or other hard substance in preference to the many types of flimsy leather or imitation-leather wallets now on the market. These wallets are doubtless very handy for carrying in the pocket, and in this respect appeal to many, but they do not protect the instruments when out of use in the way that a good wooden case will do.

Drawing-boards.—These are made in dimensions to suit the various sizes of drawing-paper. The large boards should invariably be of the "battened" variety, in which the well-seasoned pine which forms the drawing surface is fixed to two oaken battens by means of screws passing through brass-lined slots. These slots permit of the expansion and contraction of the wood without warping of the surface. The left-hand edge of the board should have a substantial ebony strip fitted into it against which the stock or head of the T-square may be made to bear.

A very suitable size of board for a beginner is 23 in. by 16 in., which takes half an "imperial" sheet of paper. These boards, about ½ in. thick, can be obtained in 3-ply wood, the 3-ply arrangement preventing warping under all ordinary variations of temperature and humidity. Such a board will be found convenient for the work contained in this book; the size of paper required is about 22 in. by 15 in.

Drawing-paper.—If the drawings are only to be finished in pencil, cartridge or machine-made paper is quite suitable for the purpose of the beginner. It should be of fairly good quality, able to stand erasure without destruction of the surface, and pencil lines made on it should not be readily smudged or blurred, even when repeated use of the rubber is found necessary. Such paper is made in continuous rolls, and also in the following sheets:—

Name of Sheet.	Size of Sheet.
Antiquarian	53″ × 31″
Double Elephant	40″ × 27″
Imperial	30″ × 22″
Half Imperial	22″ × 15″

Where drawings are to be finished by inking-in or colouring, a better quality of paper, such as Whatman N.H.P. (not hot-pressed) or rough surface, is desirable. In either case it is worthy of the beginner's notice that there is a right side and a wrong side of the paper. The right side to draw on is that next the eyes when the maker's watermark can be read correctly, the paper being held between the eyes and the light. If the paper is not watermarked, the right side can usually be distinguished by its smooth appearance compared with the rougher "squared" appearance of the back.

For sketching purposes, particularly if finished drawings are to be made from them afterwards, practically any type of paper is suitable. In this connection, the use of squared paper is sometimes a big advantage, since the two sets of lines facilitate the sketching, and details can be quickly drawn in proper proportion without the necessity of actual measurements being made. For this purpose, paper such as illustrated at A, fig. 4, is most useful. The large square has 1-in. sides, and each side is divided up into 12 equal parts, making 12 rows, each containing 12 little squares. As there are 12 in. per foot, these divisions enable one to make rapid sketches of comparatively large objects in due proportion. For certain purposes the paper ruling illustrated at B is more useful, since it is divided up into eighths of an inch in 1-in. squares. In several engineering works each inch of the foot-rule is divided into 10, and hence 10 × 10 paper would be used.

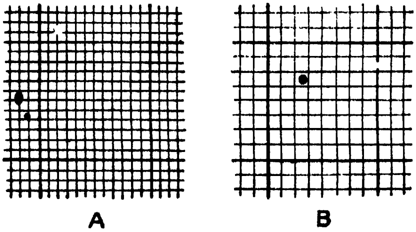

Fig. 4

T-square and Set-squares.—The T-square is used for guiding the pencil in the drawing of all lines parallel to the length of the board; it must be made of a size to correspond to the board in use—generally about an inch longer, i.e. when the head or stock is close up to the left-hand edge of the board, the end should project over the right-hand edge of the board by an inch or so. Shorter ones may, of course, be used without much inconvenience.

The best T-squares are made of mahogany, with the working edge of the stock and the ruling edge of the blade fitted with ebony strips. The beginner, however, is well enough equipped if he possesses a pear-wood or maple T-square without the ebony edges. It is essential that the ruling edge be straight, and that it lies at right angles to the stock. The stocks or heads are made either movable or fixed; the latter is to be preferred.

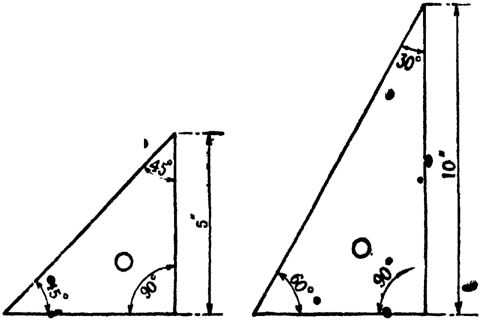

Fig. 5

Set-squares are used to draw lines at right angles, or at other fixed or "set" angles, to the line of the T-square. They are right-angled triangles made of wood, transparent celluloid, vulcanite or the like. The two kinds in most general use are illustrated in fig. 5, which shows the angles found in each, and useful sizes. They are known as the "45" and "60" set-squares respectively from the particular angles they contain, viz. 45° and 60°. The 60° angle naturally has a 30° angle as its complement, but this set-square is almost invariably named after the 60° angle.

The cheapest forms of set-squares are made of pear-wood, but they are liable to shrink and warp. A better quality is that framed up of three pieces of wood and fitted with ebony working edges, but for general use those of transparent celluloid are perhaps the most suitable. Some are made with bevelled edges, but these are in many cases inconvenient, particularly when using the set-squares to draw parallel lines, or when using the 60 set-square to draw oppositely-directed lines; on the whole, the perfectly-flat-edge variety is the best.

Rules, Scales, &c.—Possibly the best form of rule is an ordinary 12-in. steel straight-edge, marked in 8ths, 16ths, 32nds, and 64ths of an inch on one edge, 10ths, 20ths, 50ths, and 100ths of an inch on another edge, and, since metric measurements are sometimes found necessary, these may be marked on the opposite side of the rule. The one disadvantage in the use of a steel rule—apart from the formation of rust—is the possibility of blunting the points of dividers and the needle-points of compasses when taking off sizes; this defect can be avoided by placing the sides of the points into the divisions of the scale, and by exercising a certain amount of care. Cardboard scales are extensively used by engineering students, and so are box-wood scales.

Drawing-pins.—These are made in many types and sizes. A useful size is that made of bright steel, with a head about $\frac{1}{2}$ in. or $\frac{9}{16}$ in. diameter. They should be made in one piece, i.e. the pins should not be inserted, as they are liable to loosen after having been in use for some time.

When the student has made some progress, he may find it an advantage to add other tools to his outfit, such as the above-mentioned scales, protractors, curves, &c., but these will not be discussed until the need for them arises.

CHAPTER III

PRELIMINARY EXERCISES

The object of any mechanical drawing is to describe completely any particular mechanical appliance by indicating its actual shape and formation by means of surfaces enclosed by lines, straight or curved, in such a way that there is no doubt or ambiguity as to its shape or dimensions. An examination of any drawing, simple or complex, will reveal the fact that it is made up of lines. The lines may all be of one kind, but more usually there will be two or more kinds on the drawing.

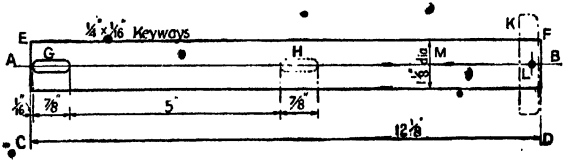

Fig. 6

The different kinds of lines are used for different purposes, as will be demonstrated by the description of fig. 6.

The lines in fig. 6 represent a working drawing of the lifter cam shaft of a certain type of spinning-frame. The drawing is built upon the thin fine line AB, known as a centre line; it may be taken as a general rule that similar centre lines form the starting-point of every mechanical drawing. The line should be perfectly even and distinct; but, as its use is merely constructional, it should not be so prominent as the main lines of the object. Sometimes the lines are made "broken" as indicated at A, fig. 7, but it is more convenient, particularly in a drawing with much detail, to have one continuous line.

The line CD in fig. 6 may be taken as typical of a second kind of line, known as a dimension line. It should be somewhat firmer, i.e. thicker than a centre line, but still not so distinct as the main outline of the object. Its purpose is to show the exact meaning of the dimension placed upon it.

The dimension CD, fig. 6, is shown to be $12\frac{1}{8}$ in., indicating that the length measured between the locating lines drawn from the ends of the shaft, and therefore between the ends of the shaft also, is to be made $12\frac{1}{8}$ in. The dimension line should be drawn as shown, and the figures written immediately above it as indicated. The line should be continuous, although some draughtsmen have a preference for the method indicated at B in fig. 7. Dimension lines are easily recognized by the arrow-heads, the angle of which should be small rather than large, and the sides long rather than short; the two types are shown at C and D, fig. 7, and the former is to be preferred.

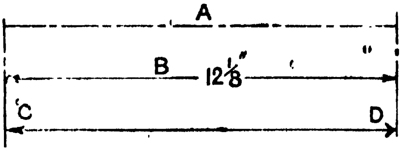

Fig. 7

The main line of the drawing in fig. 6 is indicated by EF. This should be a firm even line of one thickness throughout, drawn fairly boldly and heavily so that it stands out distinctly from all the other lines on the drawing. The student should cultivate from the very beginning the faculty of drawing lines of regular thickness; and, in any one drawing, all lines with a similar purpose should be exactly alike. This is somewhat difficult of attainment by a beginner, but it becomes easier by practice, and ultimately develops into a habit.

The dotted lines shown at H, fig. 6, serve a very useful purpose; G and H are two keyways, each $\frac{7}{8}$ in. long but 5 in. apart, as shown by the dimensions in the lower part of the figure. The keyway G is drawn in full lines, indicating that it is in the front portion of the shaft, and therefore visible; on the other hand, H is drawn in dotted lines to indicate that it is on the opposite side of the shaft, and really cannot be seen when the shaft is in the position shown. This purpose is perfectly general, and dotted lines are invariably used to indicate details which are hidden from any particular line of view; when different views are taken of the same article, a part may be in full view in one drawing, and dotted (or out of view) in another drawing.

A second kind of dotted line is used at K, fig. 6. This is known as a chain-dotted line, and is really a series of very short lines alternating with comparatively long lines. Such chain-dotted lines are used for several purposes, but mainly to convey information in a more or less graphic manner. In this particular instance the chain-dotted line indicates the outline and position of a washer used on the shaft, and is drawn with the shaft to give a reason for the small hole shown at L. The hole is intended for a cotter-pin, and such holes are not usually drilled until the part is being put into its final position on the machine. It is for this reason that the hole is neither located on the shaft nor dimensioned.

With this preliminary information the student will be in a position to make a start with actual drawing, and, since all drawings are made up of lines, the first exercises shall consist in practice in the drawing of the various kinds of lines mentioned.

Instruction.—Pin a sheet of drawing-paper to the board, and see that it lies flat on the board without buckling or creasing. It is a good plan to have a second sheet below the first to act in the nature of a pad. A soiled piece, or an old drawing will amply serve the purpose. Once the paper is in position, pin down the right-hand top corner, and then adjust the paper until its edges are parallel to the edges of the drawing-board. Then draw the right hand firmly from the pinned corner to the left-hand bottom corner, and insert there a second pin. Then, with the left hand, smooth down the paper towards the left-hand top corner, and insert a third pin. Finally, do the same smoothing process for the right-hand bottom corner and insert the fourth pin. Four pins should be sufficient for a small sheet of paper, but more may be used if it is found desirable or necessary. When the paper is properly pinned down, lay the T-square on the board as indicated in fig. 8, and have all the pencils, &c., likely to be required in readiness at the right-hand side.

EXERCISE 1.—To draw examples of various kinds of lines. Divide the sheet of paper into four divisions as shown in fig. 9. The centre of the upper and left-hand edges may be found by direct measurement, after which the T-square is used to draw the horizontal lines, and the 60 set-square, with its short edge resting on the T-square, as exemplified in fig. 8, to draw the vertical lines. It is *imperative* at all times to have the stock of the T-square held firmly to the left-hand edge of the drawing-board.

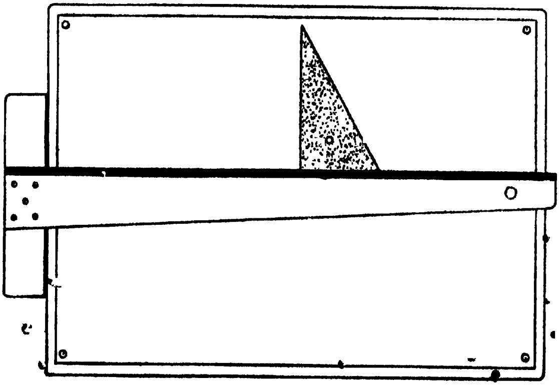

Fig. 8

In one of the four spaces formed, mark off a point about 1 in. from the left-hand edge, and with the 60 set-square set up a light vertical line. Set the dividers to ¼ in., and mark lightly a series of points, ¼ in. apart, on this vertical line. Use each of these points in succession as the beginning of a line, and draw equal numbers of centre, dimension, dotted, chain-dotted, and full lines.

EXERCISE 2.—In the second of the four spaces mark a point about 1 in. from the bottom, draw a horizontal line through it with the aid of the T-square, and on this line set off a series of points ¼ in. apart. Use these points to draw a second series of lines similar to those in Exercise 1, but vertical instead of horizontal. These vertical lines must be drawn with the 60 set-square set with its short edge against the drawing edge of the T-square, as in fig. 8, and moved successively to each point in turn without moving the T-square.

Exercise 3.—In the third space, fig. 9, draw a diagonal with the aid of the longest edge of the 60 set-square, and mark off on it a similar series of points. Use the 60 set-square to draw a third series of the different types of lines mentioned in Exercises 1 and 2, but this time at an angle of 30° to the horizontal.

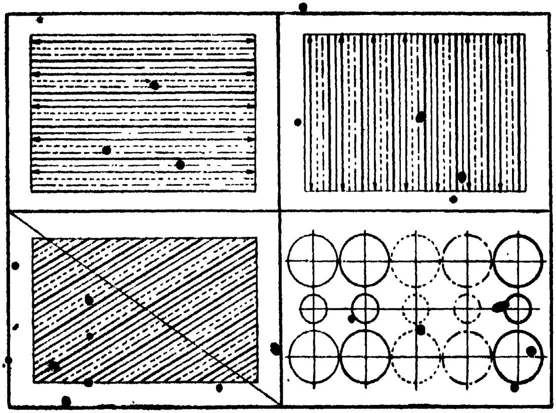
Fig. 9

Exercise 4.—In the fourth space, which, if the full sheet measures 22 in. × 15 in., will be 11 in. × $7\frac{1}{2}$ in., draw two horizontal centre lines, so that their pitch, or distance apart, is half of $7\frac{1}{2}$ in., i.e. $3\frac{3}{4}$ in. Next draw five vertical centre lines, pitched $2\frac{3}{16}$ in. apart, thus giving ten points at which the vertical and horizontal lines intersect. Set the compasses to a radius of 1 in., and, using each of the ten points as centres, construct ten circles, making two of each with lines corresponding to the five kinds used in the previous three exercises. A third horizontal centre line may also be drawn, and five additional but smaller circles may be described as shown. In drawing lines on the paper, the student should remember always to move the pencil away from him, i.e. when drawing horizontal lines, move from left to right; for vertical lines, from bottom to top; and for circles in a clockwise direction. To do otherwise is to invite the pencil to dig into the surface of the paper.

In all of the above exercises the student should endeavour to make all the lines of the same value, that is to say, each kind of line should be of the same even thickness and blackness throughout. In setting compasses to given radii, care must be taken to prevent injury to the compass points, particularly if a steel rule is used. In every case, the compass point should be laid in the marking of the rule as flat as possible, and on no account should the points be applied perpendicularly to the surface of the rule. In setting the compasses to any particular radius, it will be found an advantage to have the middle finger of the right hand between the legs of the compasses, as in this position it can best control the movement in or out of the compass pencil.

In the actual drawing of the circles, the compasses should be held at the top only, and the pencil should not be helped round by pressing one or more of the fingers directly on the pencil leg. One sweep of the compasses should complete a circle, unless it be of a large diameter; if more than one movement be necessary, care must be taken, when changing the position of the fingers, not to cause the compass point to dig into the paper, and to see that the second part of the circle joins up properly to the first part. Beginners should also be warned against having the compass joint too tight, as this practice wastes much time in setting the points to a new radius.

As one of the essentials of any form of mechanical drawing is accuracy, it is necessary to see that the instruments used, particularly the T-square and the set-squares, are first of all accurate themselves. The essentials of a T-square are:

1. That the working edge be straight; and
2. That the working edge of the blade is at right angles to the working edge of the stock.

The following two exercises will enable the student to test his T-square;

Exercise 5.—With a finely-sharpened, hard, chisel-pointed pencil draw as long a horizontal line on the paper as the T-square will allow, making sure that the stock is held firmly against the edge of the board, and that the pencil point is as close as possible to the edge being tested. Next, turn the T-square with its other face on the paper and bring the working edge down to the line thus drawn. If the edge is straight, it will coincide with the line at every point, no matter how the T-square be altered horizontally.

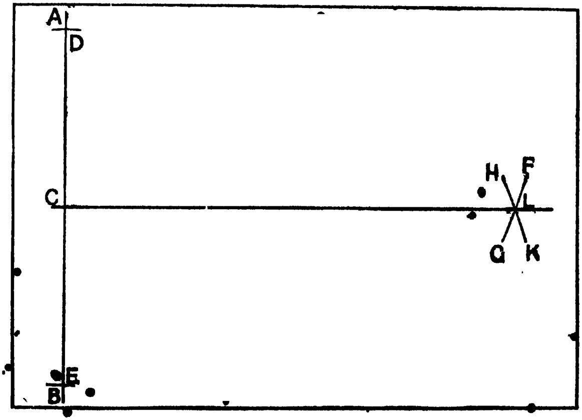

Fig. 10

Exercise 6.—To ascertain if the blade and stock of the T-square are at right angles: Near the top of the paper measure carefully, say 2 in. from the left-hand edge, and mark a fine point. Do the same near the bottom of the paper, and join these two points, A and B, fig. 10, by a straight line. Take any point C, at or near the middle of AB, and with C as centre and radius CD (as large as possible) mark off two points D and E equidistant from and above and below C. With point D as centre, and as large a radius as possible, describe the part of a circle shown at FG; repeat this from point E with the same radius, and draw the part of a circle HK, cutting FG at the point L. Join C to L. Now place the T-square in position on the board, and move its edge up to the line CL. If the stock is perpendicular to, or square with, the blade, the edge of the blade and the straight line CL will exactly coincide.

The student should note that he really has halved or bisected an angle of 180°, i.e. made two angles of 90° or two right angles, these being angle ACL and angle BCL. It will thus

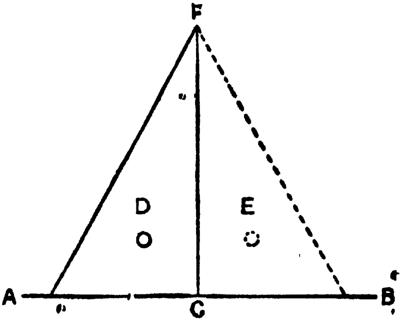

Fig. 11

be seen that CL is at right angles to AB, and since AB is parallel to the edge of the board, and to the stock of the T-square, CL must also be at right angles to the stock.

The essentials of the set-squares are:

1. That their edges be straight; and
2. That the various angles are exactly what they purport to be.

The straightness of the edges may be tested by reference to any known straight edge, or by the method indicated in Exercise 5, while the following two exercises show how to check the various angles:

Exercise 7.—To test the 90° angle of a 60 set-square: With the aid of the T-square draw a horizontal line similar to AB, fig. 11. Assume a point C at or near the centre of

AB, and with the short side of the 60 set-square held against the T-square in the position indicated by D, draw a line along its upright edge. Without altering the position of the T-square, turn the set-square over on its other side into the position indicated by E on the right, and see that the vertical edge coincides exactly with the line CF; if it does, the angle ACF is 90° and therefore correct. The right angle of the 45 set-square may be tested in a similar manner.

EXERCISE 8.—Draw a horizontal line AB, as in fig. 12, and

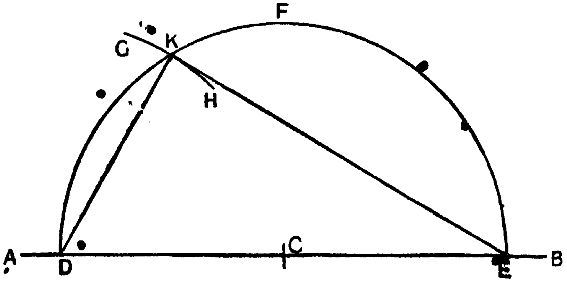

Fig. 12

assume a point C at or near the centre. With centre C and radius CD, describe the semicircle DFE. With the same radius, and D as centre, describe the part circle or arc GH, cutting the semicircle in K. Join DK. The angle CDK, or EDK, is now 60°, and may be used to check the 60° angle of the set-square.

If the 90° and the 60° angles are thus found to be correct, and if it has previously been proved that the edges of the set-square are straight, the 30° angle may be taken as correct, since the three angles of any triangle are equal to 180° or two right angles; $180 - (90 + 60) = 30$. If a further and more graphic check is desired, join KE. Angle DEK is an angle of 30°, and may be used to test the 30° angle of the set-square. *Euclid*, III, 31, proves that the angle in a semicircle is always a right angle, hence the triangle DKE is exactly similar to a 60 set-square, and the 90° angle of the set-square may be further checked by reference to the angle DKE.

Exercise 9.—To test the 45 set-square, draw a horizontal line AB as in fig. 13, and assume a point C at or near one end. Use the 60 set-square to set up a line CD perpendicular to AB. With centre C, and radius CE, describe the quarter-circle EF. With centres E and F describe the arcs GH and KL respectively, intersecting at M. Join CM. The angles ECM and FCM are each 45° (half a right angle) and may be used to check the small angles of the 45 set-squares.

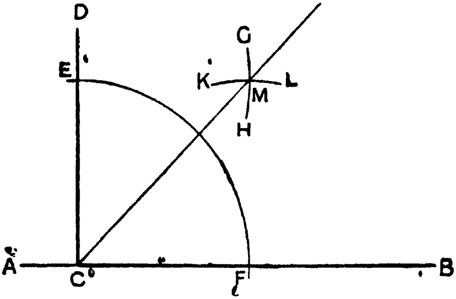

Fig. 13

The student should again note that the construction shows how to bisect any angle, that is, to divide it into two equal parts. In the case in fig. 13, an angle of 90° (a right angle) is thus bisected, whence each half becomes $\frac{90}{2}$ or 45°.

A further method of checking the set-squares is sometimes suggested, but its accuracy depends on the taking of very exact measurements. Thus, in a 60 set-square the long edge opposite the right angle should be exactly twice the length of the shortest side, while in a 45 set-square the sides adjacent to the right angle are equal. The difficulty in checking by this method lies in the fact that when set-squares have been in regular use, for even a short time, the points at the angles become rounded by wear, and accurate measurement is almost impossible.

CHAPTER IV

CONSTRUCTION OF LINES, CIRCLES, AND ARCS, AND SIMPLE PLANE GEOMETRY

Any mechanical drawing may be regarded as a combination of various lines, straight and curved. Both are generally present in most drawings, sometimes separately, but often in conjunction. In many cases curved lines, arcs, circles, &c., have to be joined on to, or meet, straight lines, and the correct joining up of straight and curved lines has much to do with the good appearance and accuracy of the drawing. The following exercises are intended to give the beginner practice in the use of the various drawing-instruments, and to inculcate habits of neatness and accuracy. When any general geometrical principle is involved, it will be discussed briefly, and mainly from the point of view of its application to mechanical drawing. It need hardly be pointed out that if the student intends to become expert in mechanical drawing, it is desirable that he should have a more or less extended knowledge of the principles of plane and solid geometry.

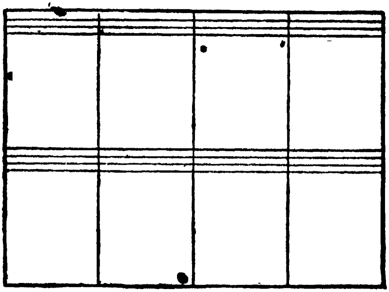

Fig. 14

It will be convenient if the student divides his sheet of paper into divisions, as shown in fig. 14, where the paper is divided into eight rectangular spaces. Near the top of each row of four spaces draw three light lines as shown, and use them to indicate briefly the nature of the various exercises, and to make any notes concerning them. With regard to the actual line drawing, it should be borne in mind from the commencement that many of the lines are used solely for constructional purposes. These should be drawn as lightly, as finely, and as accurately as possible, and only on completion of the exercise, when the object has been attained, should the important lines be ruled in distinctly.

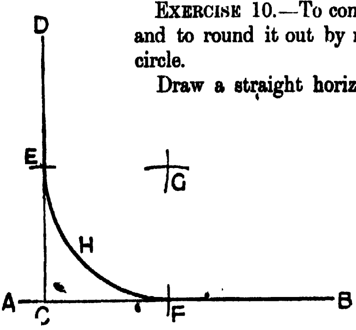

Fig. 15

EXERCISE 10.—To construct a right angle, and to round it out by means of an arc of a circle.

Draw a straight horizontal line AB, as in fig. 15. Choose any point C near A, and by means of the 60 set-square set up a perpendicular CD. If the radius of the arc is to be 1½ in., take this radius upon the compasses, and, with point C as centre, strike two short arcs, cutting CD in E and CB in F. Keeping the same radius, and with E and F as centres in succession, mark the two small arcs shown intersecting at G. Then G is the centre of the required arc; hence, with G as centre, and the same radius of 1½ in., draw the arc EHF as shown. If accurately drawn, DEHFB should appear as one continuous line—straight, curved, and straight.

Repeat the same exercise, using different radii for the required arcs.

EXERCISE 11.—Construct an angle of 45° without using the 45 set-square, and round out the two sides by means of an arc of a circle.

Draw a horizontal line AB, fig. 16, and from a point C on it set up the perpendicular CD by means of the 60 set-square. Take any radius less than either CD or CB, say about 2 in., and, with C as centre, strike arcs cutting CD in E and CB in F. With the same radius and centres E and F mark the arcs shown intersecting at G. Join CG. The line CG divides the angle into two equal parts, i.e. it bisects the angle DCB of 90°, and each of the angles DCG and BCG is thus 45°. Suppose that the angle BCG is to be rounded out by means of an arc of 1 in. radius. Set 1 in. upon the compasses, and choose any points H, J, K, and L on GC and CB. With each of these points in succession as centres draw the arcs indicated at M, N, P, and Q. Draw lines RS and TU, just touching each pair of arcs; these lines cut or intersect at point V, which is the required centre of the arc. With V as centre, and 1 in. as radius, describe the arc which clearly rounds out the 45° angle.

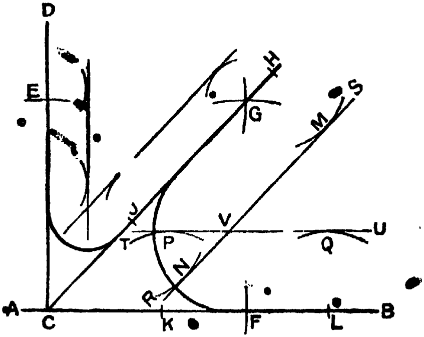

Fig. 16

Repeat the exercise, using the angle DCG and a radius of ½ in.

EXERCISE 12.—To join two parallel lines by means of a quarter-circle.

Draw a light line AB, fig. 17, using the T-square, and choose a point C in the line near A. From C, with the aid of the 60 set-square, set down a perpendicular CD. If the lines are to be 2 in. apart, take a radius of 2 in. on the compasses, and with C as centre draw the arc EHK, cutting CD in E and AB in K. Through E draw FG parallel to AB. Then with K as centre, and with the same radius of 2 in., draw the required quarter-circle CLM.

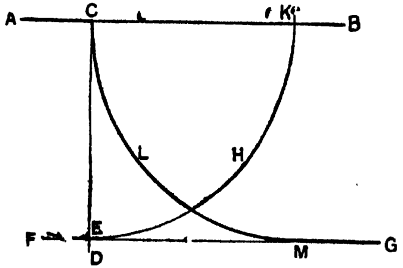

Fig.

EXERCISE 13.—To connect up a circle or part of a circle and a given straight line by means of an arc, $1\frac{1}{4}$ in. radius.

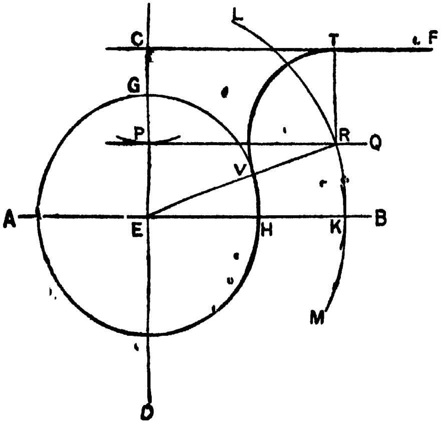

Fig. 18

Draw two lines, AB and CD, fig. 18, perpendicular to each other, and intersecting at E, and let E be the centre of the given circle. Let the centre of the circle and the given line be, say, 1¾ in. apart. Mark off the point C at a distance of 1¾ in. from E, and draw CF parallel to AB, the former being the given line. Construct a circle about E so that the point G is less than 1¼ in. from C. From point H mark off HK = 1¼ in., and with E as centre and EK as radius draw the arc LKM. With C as centre and 1¼ in. radius, cut off CP and draw PQ parallel to CF, cutting the arc LKM in point R.

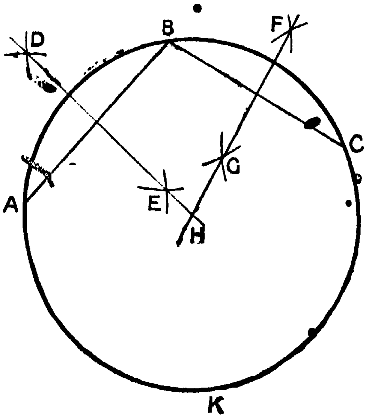

Fig. 19

R is the centre of the required arc. With R as centre, and 1¼ in. radius, draw the arc TV, joining up the given line CF to the given circle.

If a perpendicular be raised from the centre R to the line CF, it will meet CF in the point T, and this point is where the straight line FT and the arc TV meet. If RE be joined, it will cut the circle in V. These points, V and T, are termed points of contact.

Exercise 14.—To find the centre of a circle, given three points in its circumference.

Mark any three points, say A, B, and C, in fig. 19, taking care that the lines AB and BC which connect the three points form, if possible, approximately a right angle. This precaution is taken so that the circle will not have too large a radius for the capacity of the paper. When AB and BC are joined as shown, set the compasses to a radius longer than half of AB, and, with points A and B in succession as centres, describe short arcs on each side of AB, intersecting at D and E respectively. Repeat the operation with the line BC, obtaining two sets of arcs which cut at F and G respectively. Join DE and FG as shown, and, if the lines do not intersect, produce them in the required direction until they do intersect, as shown at H. Then H is the centre of the required circle, and HA, HB, and HC are radii. With this common distance HA, HB, or HC as radius, describe a circle ABCK as indicated. Note that the lines DE and FG bisect AB and BC respectively at right angles. From the construction, HA must equal HB, and similarly HB must equal HC, each being equal to a radius of the circle.

Perhaps a more common problem in practice is the finding of the centre of a circle an arc of which is given. To proceed, then, draw a circle of about 3 or 4 inches radius on a piece of thin cardboard, and cut it out carefully with a sharp knife or scissors. Divide it into two segments, one less and one greater than a semicircle. Lay the lesser one on the drawing-paper, and draw carefully round the curved portion of it. This will give an arc of a circle the centre of which is not marked.

EXERCISE 15.—Given the arc of a circle, to find its centre and radius and to complete the circle.

Suppose ABC in fig. 20 to be the arc obtained as described above. Choose a point B near its centre and join AB and BC. Proceed next, as in Exercise 14, to bisect AB and BC at right angles, and thus find the centre D. With DA, DB, or DC as radius, complete the circle as shown in heavy chain-dotted lines. The student will probably see that it is not absolutely necessary to join up the points AB and BC by lines.

EXERCISE 16.—To connect two given circles by an arc of a third circle of known radius.

Suppose the two circles are 3 in. and 2 in. diameter respectively, and that their centres are 4 in. apart, while the third circle connecting the other two has a radius of 1½ in.

Draw a horizontal centre line, and mark two points on it in. apart, as A and B, fig. 21. With centres A and B, and

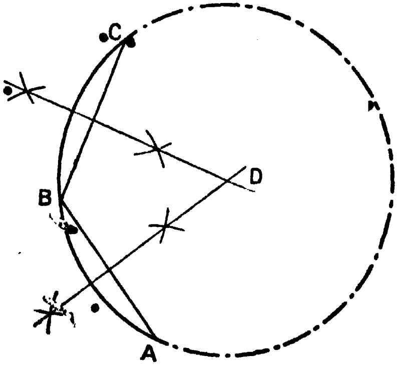

Fig. 20

radii of 1½ in. and 1 in. respectively, describe circles of 3 in. and 2 in. diameters. With centre A and radius 1½ in. + 1⅛ in. = 2⅝ in., describe arcs CD and EF; and with centre B and

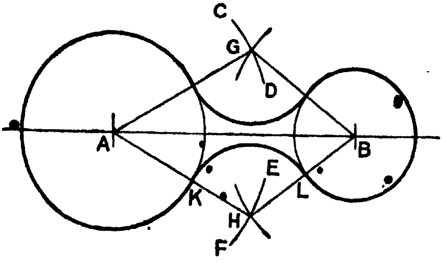

Fig. 21

radius 1 in. + 1⅛ in. = 2⅛ in., describe two other arcs, cutting the first two arcs at G and H. The centres of the two 1⅛-in. arcs are G and H; so with these two joints as centres, and a radius of $1\frac{1}{8}$ in., connect up the given circles by the arcs shown.

The accuracy of the drawing may be tested by joining A to H and H to B. AH and HB cut the circles at K and L respectively, and, if the drawing is accurate, points K and L will coincide with the points where the $1\frac{1}{8}$ in. radius circle joins the other two circles, i.e. K and L are the points of contact.

Exercise 17.—From any point on a given circle to draw a tangent to the circle.

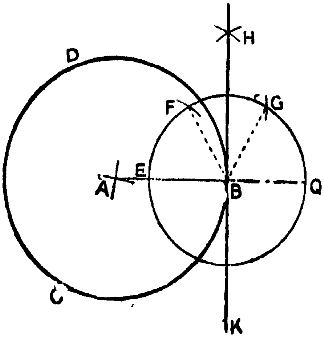

Fig. 22

With any suitable point A, fig. 22, as centre, and a radius of, say, 1 in., draw the circle BCD. On the circumference of this circle choose any point B through which the tangent to the circle is to be drawn.

Join AB, a radius of the circle. The required tangent must pass through B and lie at right angles to the radius AB; any construction, therefore, will be appropriate that enables a right angle to be formed at the point B. One method is as follows: With B as centre, and a radius of, say, BE, draw a second circle EFG; with the same radius BE, mark off on the circumference the divisions EF and FG, each of which subtends an angle of 60° at the centre of the circle. With centres F and G in succession, and any suitable radius, draw the arcs intersecting at H, and through H draw HB and extend it to point K. HK is the required tangent.

Each of the angles EBF and FBG is 60°, as indicated above; while HB bisects angle FBG. The angle EBH is thus equal to $60° + \frac{1}{2}$ of $60° = 90°$, a right angle, and the line HBK is thus at right angles to the radius AB, i.e. it is a tangent to the circle BCD.

The student should repeat the exercise by prolonging AB, so that BQ = EB; then obtain the point G from point Q, instead of from point F.

EXERCISE 18.—From a point outside a given circle draw two tangents to the given circle.

With centre A, fig. 23, and a radius of $1\frac{1}{8}$ in., describe the circle DEC. Outside this circle, choose any suitable point B from which to draw the two tangents. Join AB, and bisect it at right angles in the point O, using the method given in Exercise 14. With point O as centre, and OA or OB as radius, describe the circle ACBD, cutting the given circle in C and D. Join BC and BD, and produce them to F and G respectively; BF and BG are the required tangents.

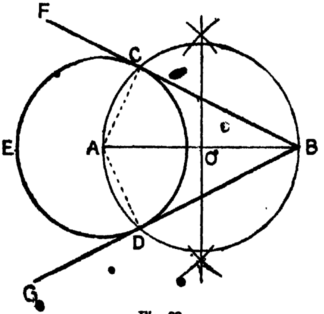

Fig. 23

Join AC and AD: these are two radii of the given circle DEC. Note that AOB is a diameter of the circle DACB, and that ACB and ADB are thus semicircles. It has already been stated that the angle in a semicircle is a right angle; hence, angle ACB and angle ADB are right angles. The lines BF and BG are therefore each at right angles to a radius of the given circle, i.e. BF and BG are tangents.

EXERCISE 19.—To describe a circle to touch the three sides of an equilateral triangle of 4-in. side.

Draw a straight line AB, fig. 24, fully 4 in. long, and by means of the compasses, set to 4 in., mark off points C and D. With points C and D as centres, and with the same 4-in. measurement, mark off the arcs intersecting at E. Join CE and DE. CDE is the required equilateral triangle of 4 in. side.

Proceed as follows to find the centre of the required circle.

With a radius greater than half of CD, say 3 in., and with D and E as centres in succession, strike the arcs intersecting at F. Repeat this from points C and E, and obtain the point G. Join CF and DG, noting that they intersect at H, which is the required centre. As a check, drop a perpendicular from E upon the base CD; this line should also pass through the point H.

With H as centre, and HK, HL, or HM as radius, describe the required circle. This circle is termed the "inscribed circle", H is the median centre, and the lines CM, DK, and EL are called medians, because they pass through this centre. The medians bisect their respective angles, and also bisect the sides at right angles. H is also the centre of area of the triangle CDE.

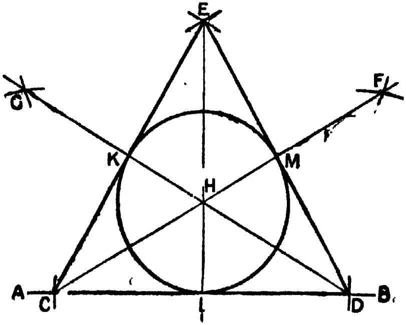

Fig. 24

EXERCISE 20.—To construct a square of 4-in. side, and to inscribe a circle touching each of the four sides.

With the aid of a T-square draw a horizontal line AB, fig. 25, fully 4 in. long. From A set up AC, by means of the 60 set-square, perpendicular to AB, and also a little more than 4 in. long. Set the dividers to 4 in., and, with A as centre, mark off the points D and E on AB and AC respectively. Through E draw EF parallel to AB, and through D draw DG parallel to AC, and meeting EF in G. Then ADGE is the required square.

Join AG and DE; these lines intersect at H, and this point is the centre of the square as well as the centre of the required circle. To find the necessary radius, set up KL through H parallel to AE and DG, and also through H draw MN parallel to AD and EG. HK, HM, HL, and HN each gives the radius required, so with centre H, and radius as shown, describe the circle KLMN, the points named being the four points of contact. Note that H is the centre of area of the square, that the diagonals intersect at right angles, and that each diagonal bisects the square as well as the horizontal and vertical centre lines.

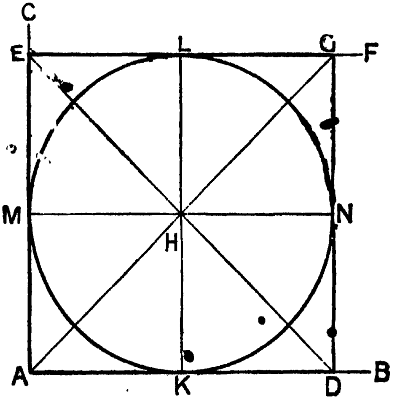

Fig. 25

The student will find it a useful exercise to tabulate in his notebook the above facts, as well as any others he may learn from each problem.

Exercise 21.—To describe, within a square of 4-in. side, four equal circles, each circle touching two sides of the square and two other circles.

Using the same means as employed in Exercise 20, describe a square ABCD, fig. 26, of 4-in. side, and on the base AB. Join AC and BD; these diagonals intersect at O, the centre of the square. Use the T-square and the 60 set-square to draw EF and GH, each passing through O. The given square is now divided into four equal small squares AHOE, HBFO, OFCG, and EOGD.

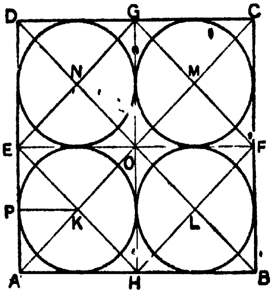

Fig. 26

Draw the diagonal HE, intersecting AO at K, the centre of the small square AHOE, and from K draw KP parallel to AH. K is the centre, and KP the radius, of one of the required small circles.

In a similar manner, find the centres L, M, and N, and, with each of the points K, L, M, and N as centres in succession, and the length KP as radius, describe the required circles. It will be seen that each circle touches two sides of the given square, and also two other circles: the required conditions are thus fulfilled.

The last exercise may have little practical value, but it is useful on account of the accuracy required in measurement, and in the use of the instruments in order to obtain a neat and accurate result. The same remarks apply to the next exercise.

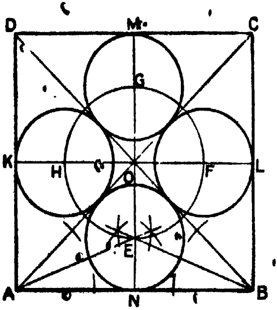

Fig. 27

Exercise 22.—To describe within a square of 4-in. side, four equal circles, each circle touching one side of the square and two other circles.

On a base AB, fig. 27, construct a square of 4-in. side, and draw the diagonals AC and BD intersecting at O, the geometrical centre of the square. Use methods similar to that shown in Exercise 24 to bisect the angles OAB and OBA; the bisectors intersect at E. With O as centre, and OE as radius describe the constructional circle EFGH, and through O draw the horizontal and vertical centre lines KL and MN, cutting the circle EFGH at H and F, and E and G respectively.

Before proceeding further, it should be noted that the bisectors AE and BE intersect at E, which is itself a point on the centre line MN. If the student should find it otherwise, his drawing is inaccurate in some respect, and steps should be taken to correct it.

The points E, F, G, and H on the constructional circle are

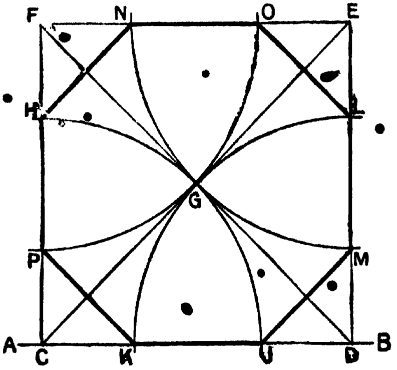

Fig. 28

the centres of the four required circles, and EN, FL, GM, and HK, being equal, give the necessary radius. With each of these points in succession, describe circles with the radius indicated. If correctly drawn, each circle will touch one side of the square and two other circles, and will therefore fulfil the conditions stated in the exercise.

Exercise 23.—To construct a regular octagon within a square of 3-in. side.

Draw a horizontal line AB, fig. 28, fully 3 in. long, and, using methods similar to those discussed in Exercise 20, describe the square CDEF. Find the centre of the square by drawing the diagonals CE and DF, noticing that they intersect at G. Each diagonal bisects the other, so that GC, GD, GE, and GF are all equal. With, say, GC as radius, and with points C, D, E, and F in succession as centrés, describe arcs each of which passes through the centre G, and each of which cuts two adjacent sides of the square, the latter points being lettered H, J, K, L, M, N, O, P. Join up these points as indicated, and obtain the octagon shown.

The regularity of the octagon may be checked by taking the length of one side, say PH, on the dividers, and testing the length of each side in succession. If carefully drawn, all the sides will be found equal. It will be evident that the angle PCK is a right angle, and, since each of the angles CPK and CKP are equal, each will be 45°. The regularity of the octagon, as regards the size of its angles, may thus be checked by the aid of the 45 set-square, which should show that all the corresponding angles are 45°.

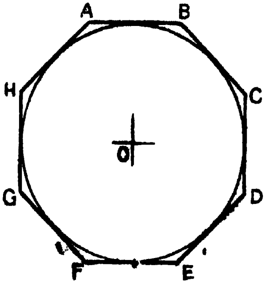

Fig. 29

The student should now be able to state the size of the angles of the octagon, that is, of angles HPK, PKJ, &c.

EXERCISE 24.—To draw a regular octagon about a given circle of 2 in. diameter.

With any suitable point O as centre, fig 29, and a radius of 1 in. (equal to a diameter of 2 in.) describe a circle. Use the T-square to obtain the sides AB and EF, drawing each tangent to the circle. Draw next the vertical sides CD and GH, making use of the 45 set-square, resting one of its edges on the T-square. Complete the octagon by turning the 45 set-square so that its long edge rests on the T-square and draw in the sides BC and FG, and then DE and HA.

The first four sides (the horizontal and the vertical ones) should be drawn lightly, and a little longer than is absolutely required. The four diagonal sides can be drawn in boldly the proper length, after which the first four can be lined in to correspond. Any line, or part of line, not required, may then be removed.

EXERCISE 25.—To describe a regular hexagon about a circle of 3 in. diameter.

Draw a horizontal centre line AD, fig. 30, fully 3 in. long, and choose any point O near its centre. With O as centre, and a radius of 1½ in. (equal to 3 in. diameter) describe a circle. With A and D as centres, and the same radius, describe arcs passing through the centre O, and cutting the circle at B, C, E, and F. The circumference of the circle is thus divided into six equal parts, i.e. the distances AF, FE, ED, &c., are all equal. Join BE and CF. The outer points of the six radii OA, OB, OC, &c., are now equidistant; lines drawn at right angles to them at points A, B, C, &c., will be tangents to the circle. These lines may be drawn in several ways, one of which is indicated below.

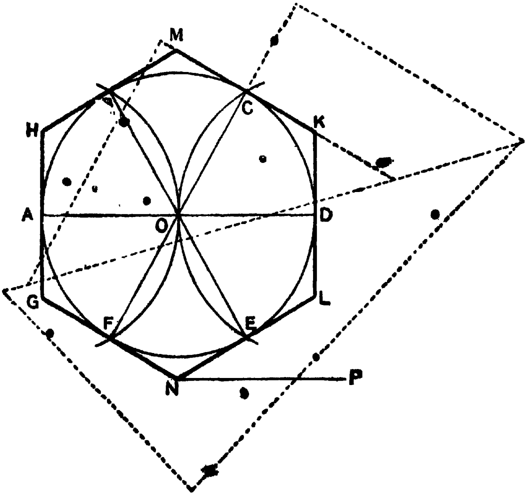

Fig. 30

The vertical sides GH and KL may be drawn by the usual method with the 60 set-square and the T-square. The other sides may be drawn at right angles to their respective radii by placing the 60 set-square in the position indicated by the dotted lines, and then placing the long edge of the 45 set-square against the long edge of the 60 set-square with one of the short edges of the 45 set-square, the left-hand one, coinciding with the line OC. Move the 45 set-square, without moving the 60 set-square, until the right-hand short edge of the 45 set-square coincides with the point C; now draw the side KM. Each of the remaining oblique lines may be drawn in a similar manner, thus completing the hexagon.

From point N draw the horizontal line NP. Check the angle LNP with the smallest angle of the 60 set-square; the result should suggest to the student a simple method of producing a regular hexagon.

Hexagonal material being much in use for nuts, certain studs, &c., the student should note that the size of the hexagon is denoted by the distance AD, termed the *width across flats*; while, in many cases, it is also important to know the distance MN, termed the *width across corners*.

EXERCISE 26.—To construct an ellipse, given that the major axis is 4 in. and the minor axis 2 in.

Select any point as centre and through it draw horizontal and vertical lines as indicated in fig. 31. From this centre, and with a radius of 1 in. (half of 2 in., the minor axis), describe the smaller circle. With the same centre, and a radius of 2 in. (half of 4 in., the major axis), describe the larger circle. AB is thus the minor axis of 2 in., and CD the major axis of 4 in.

The next step is to divide the circumference of the larger circle into any even number of equal parts. A convenient number for the present purpose is 12, as this division may be readily obtained with the T-square and the 60 set-square. Place the short edge of the 60 set-square against the T-square, and draw the diameter marked EF; reverse the set-square, i.e. turn it over on to its other side, and draw the diameter marked GH. Place the 60 set-square now with the long edge adjacent to the right angle next the T-square, and draw the diameter JK; reverse the set-square and draw the diameter

LM. The two circles are now divided into twelve equal parts as indicated by the solid lines. A further twelve intermediate points may be obtained if desired by laying the 60 set-square on the T-square with the long edge adjacent to the right angle next to the blade of the T-square, and placing the long edge of the 45 set-square next to that of the 60 set-square. This will enable the student to divide the circle as shown by the dotted radii, and thus obtain twenty-four points on the circumferences, which will enable a more accurate curve to be drawn.

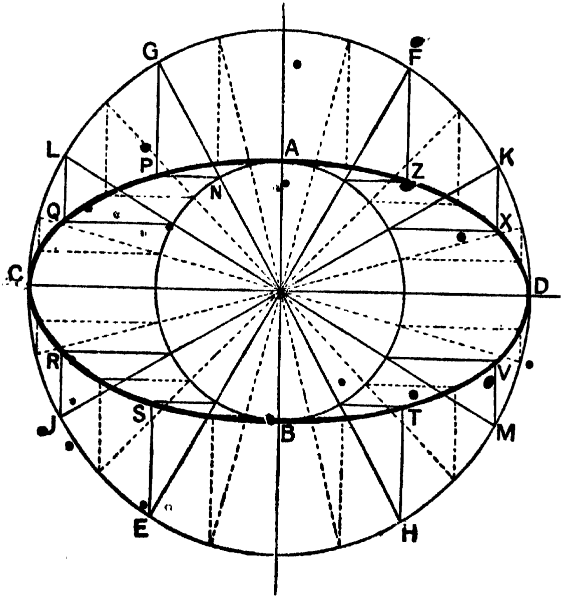

Fig. 31

A, B, C, and D, fig. 31, are four points of the ellipse, because these points are the extremities of the major and minor axes. Other eight points may be obtained in the following manner: from point G drop a perpendicular to meet a horizontal from point N. These lines meet at P, which is a point on the ellipse. In a similar way, find the points Q, R, S, T, V, X, and Z.

A fair curve can be obtained by drawing through the twelve points, and this would yield the required ellipse. It will be understood, of course, that a more accurate curve will result if the additional twelve dotted sets of lines are used, and, in general, the gracefulness of the curve of the ellipse will improve as the number of divisions is increased.

CHAPTER V

ORTHOGRAPHIC PROJECTION

A point, as defined by geometry, has no dimensions, it merely has position; it cannot, therefore, actually be represented by drawing. In practice, however, the positions of points, or rather the dots that are used to represent them, must have size, so that, when particular points in any object have to be located, the exact centres of these dots really represent the points required.

Similarly, the geometrical definition of a line is that it has length and position only, and hence no breadth. The actual lines of a drawing must, obviously, have breadth; indeed, the quality of the lines employed, as indicated by their breadth, and their mode of construction (full, dotted, chain-dotted, &c.), may be made to serve very useful purposes. This phase is clearly shown in Chap. III, with reference to fig. 6. The intersection of two lines is a point, and, in many cases, centres in mechanical drawings are indicated by the crossing or intersection of two lines.

A plane surface has two dimensions, length and breadth; it may be represented quite clearly on a sheet of paper, since the surface of the paper is itself a plane, and has length and breadth. One view only, such as the square in fig. 27, the hexagon in fig. 30, or the octagon in fig. 28, is sufficient to represent completely the shape and dimensions of a plane surface.

A solid has three dimensions, viz. length, breadth, and height; the last dimension is also termed depth or thickness, while breadth in some cases is replaced by width. These three dimensions, in a mechanical drawing, have to be represented by lines on a surface of paper having only two dimensions. It follows that it is impossible to represent any solid fully and without ambiguity by one view only, since that one view is solely capable of exhibiting two dimensions. Perspective and isometric drawings are not considered to be true mechanical drawings, because they do not exhibit true dimensions. The above three dimensions may be length and breadth, or length and depth, or breadth and depth. Hence, at least two views are necessary to represent any solid, since only by drawing two views can length, breadth, and depth be simultaneously shown.

In practice, certain types of solids are regularly represented by one view, but in such cases the remainder of the essential information is conveyed by words or written description rather than by the drawing itself. Fig. 6, for example, is an actual working drawing of a cam shaft, and one view only, that which shows length and depth, is drawn. The lines drawn inclose a flat rectangular surface, but the solid nature of the shaft, i.e. the diameter of $1\frac{1}{8}$ in. is indicated by the dimension at M; the word diameter indicates that the shaft is circular in section. This method is commonly employed for all regular sections, e.g. circular, square, rectangular, and for plain shafts, pins, studs, bars, and the like.

In the great majority of drawings, two views at least are necessary; sometimes three different views are essential to prevent ambiguity; in certain complicated cases, four and even more views may be required to render the details of construction more easily understood.

When two or more views are necessary, they must be developed from each other by the method of orthographic projection. To obtain a clear understanding, the student should provide himself with a sheet of paper, a pencil, and a rectangular box, or book, or some similar simple solid. Fold the paper across the line XY, as indicated in fig. 32, and lay the part XYDC flat on the drawing-board, at the same time setting up the part XYBA vertically. XYDC is thus a horizontal plane, and XYBA is a vertical plane; the intersection of these two planes is invariably termed the XY line in geometry,

Now place the box, or similar object, in the position indicated. Take the pencil, and draw lines on the paper in close

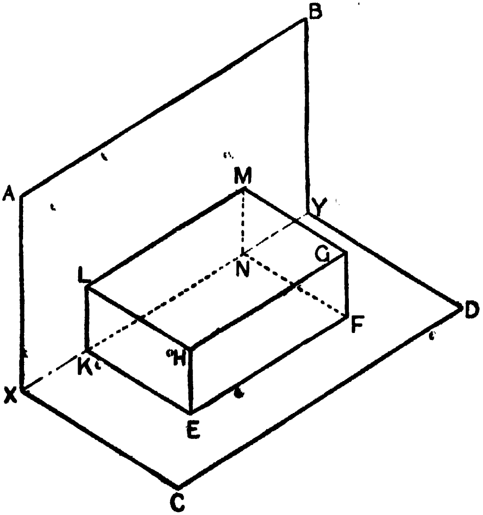

Fig. 32

contact with the lower edges of the box, i.e. KEFN on the horizontal plane. Repeat the process on the vertical plane, along the back edges of the box, KLMN; the common line KN will be formed by part of the crease XY. Take away the box, and restore the original flat surface of the paper; the latter will then appear as in fig. 33. KEFN is the projection of the box on the horizontal plane, and is called the PLAN; it exhibits the length and breadth dimensions of the box. LKNM is the projection of the box on the vertical plane, and is termed an ELEVATION; it exhibits the length and depth dimensions of the front part of the box, and is therefore a front elevation. The complete figure LKEFNM thus shows the three dimensions of the box, length, breadth, and depth, on the plane surface ABDC, which, as its name implies, possesses only length and breadth.

It is not usual to show the two projections in one view; it is much more useful to show them separately. This may also be done on a plain sheet of paper by supposing that, when the paper is doubled to obtain horizontal and vertical planes, the box does not rest directly on either of the planes, but that it is situated a certain distance from each. Suppose, for example, the box is 3 in. long, 2 in. broad, and 1 in. deep, and that it is separated from each of the planes by 1⅛ in.; it would then appear as in fig. 34. A box so placed enables one to illustrate, perhaps more clearly than that in fig. 32, the actual process of projection. The outline of the box cannot now be drawn directly upon the horizontal and vertical planes, but must be *projected* across the intervening space, i.e. the student draws on

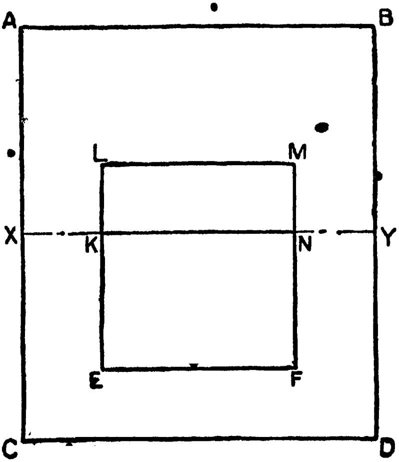

Fig. 33

each plane what he would see on such plane by imagining his eye to be placed successively in the same line as every point on the contour of the box or other article.

These projectors, as they are called, are not always shown upon the drawings, but, as preliminary exercises, the beginner may find it useful to make them, removing them afterwards with the aid of rubber. The four projectors are indicated, in fig. 34, by the light lines EE_1, FF_1, NN_1, and KK_1, the four points thus projected enabling the plan to be drawn. The other projectors KK_2, LL_1, MM_1, and NN_2 enable the elevation to be drawn.

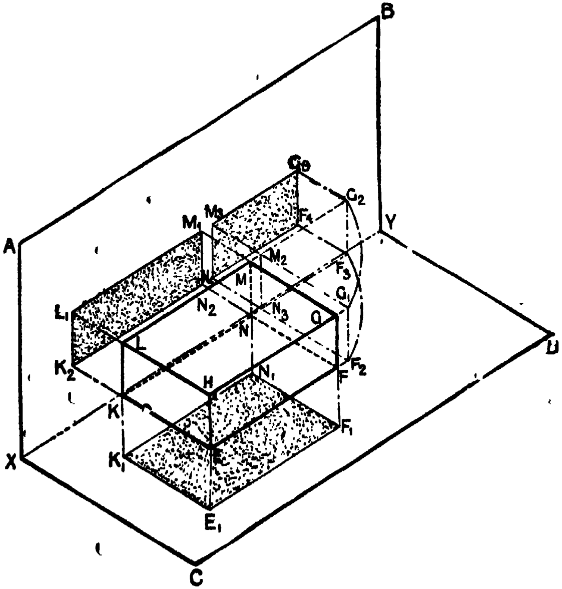

Fig. 34

When the paper is restored to its original flat condition, the plan and elevation would appear as shown in fig. 35, $K_1E_1F_1N$

being the plan, and $K_2L_1M_1N_2$ being the elevation. Since the box was placed $1\frac{1}{8}$ in. away from each of the planes, the distance separating the two views in fig. 35 will be $1\frac{1}{8}$ in. + $1\frac{1}{8}$ in. = $2\frac{1}{4}$ in.

It has already been pointed out that the object of a mechanical drawing is to *exhibit* all the essential dimensions,

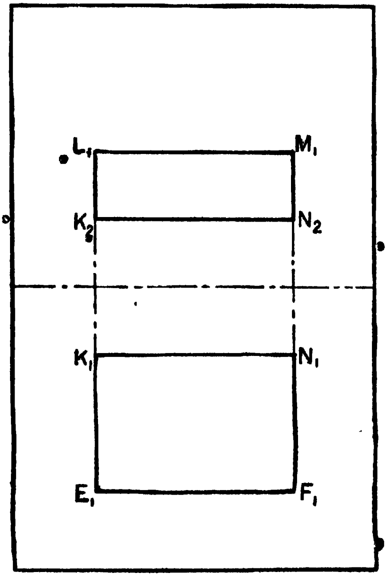

Fig. 35

and the shape of the object, without ambiguity; in many cases this can be done by drawing two views. A little consideration will show that in connection with fig. 34 a third view may be desirable, while in other somewhat similar cases it would be necessary. Fig. 35 undoubtedly represents the plan and elevation of a rectangular solid—say the box in fig. 34—but it might equally well be the plan and elevation of a wedge-shaped object, or of some more irregularly shaped object. To prevent any confusion, an *end elevation*, or two elevations, should be drawn.

Consider again fig. 34, and suppose for a moment that the box has been moved ¼ in. to the right, so that the line MN occupies the position M_2N_3; now suppose the line M_2N_3 (actually the line MN) of the box to be stationary, and the whole box made to rotate through a right angle, with the face KEFN remaining parallel to the horizontal plane; the end of the box will ultimately take up the position indicated in dotted lines $M_2N_3F_3G_2$, and the points may be projected on to the vertical plane to obtain the end elevation $M_3N_4F_4G_3$ shown stippled.

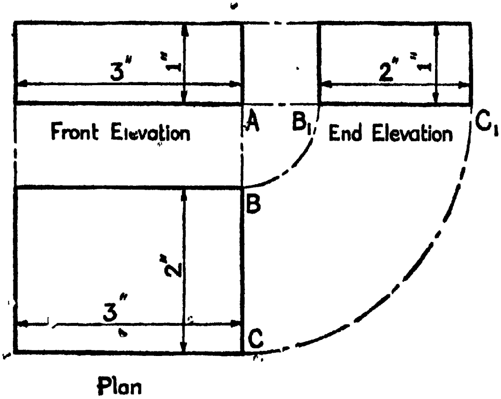

Fig. 36

If the process is conducted exactly as mentioned above, the front and end elevations would be separated by ¼ in., but there is no reason why the end elevation should not be moved, say, 2¼ in. to the right of the front elevation, thus leaving all three views quite separate, as indicated in fig. 36. The chain-dotted lines in this view indicate a second method of obtaining the end elevation. By projecting lines from the front elevation the height or thickness of the end elevation may be obtained

Next, using point A as centre, and AB as radius, swing round the arc BB_1; with the same centre, and AC as radius, draw the arc CC_1. B_1C_1 is the length of the end elevation, and these points B_1C_1 enable the end elevation to be completed. In practice, it is usual to draw the elevation of the right end at the left side, and the elevation of the left end at the right side; this assumes that the paper has been doubled along a vertical line, and the projections made as before. Note that the length of the object is shown in the front elevation and in the plan; the breadth or width is shown in the plan and in the end elevation; while the height, depth or thickness, and the breadth or width are shown in the front and end elevations respectively.

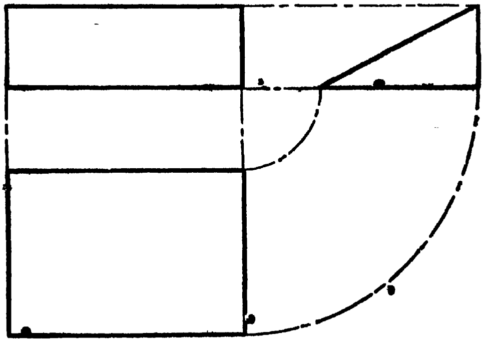

Fig. 37

It has just been stated that the front elevation and the plan of the above rectangular box might equally well have been those of a wedge, but in the case of a wedge all doubts would be set at rest by showing the end elevation, which would appear as indicated on the right in fig. 37.

The three views indicated in fig. 36, and in fig. 37, are those that are most commonly used and considered necessary, but it should always be kept in mind that the correct number of views to draw is the smallest number that will represent completely the delineation of the object on paper. In certain complicated objects, a plan and a front elevation are always drawn, but besides these there may be two end elevations, and any number of *sections* or sectional drawings. Sections are special views drawn to exhibit the details of the shape of the object across certain planes, i.e. other than the outer planes, and various methods of drawing them will be demonstrated in subsequent examples. The introduction of sections from complicated mechanism renders it unnecessary to introduce such particulars in the shape of dotted lines on the main drawings; the latter may, therefore, appear comparatively clear.

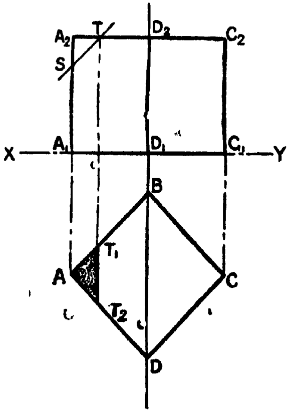

Fig. 38

The actual drawing of the following progressive examples should give the student a useful working knowledge of the making of simple plans, elevations, and sections.

EXERCISE 27.—Draw the plan and elevation of a cube of 2-in. side, resting on one of its faces on the ground, so that all the angles of that face are inclined at 45° to the XY line.

Draw a light horizontal line XY, as in fig. 38. Use the 45 set-square to construct the square shown at ABCD, making all the sides 2 in. long; this square is the plan of the cube when the cube is placed in the position described.

From each of the four corners, ABCD, and perpendicular to the line XY, set up the projectors indicated; then from the XY line, which in this case represents the ground-line or level, measure up 2 in., A_1 to A_2, the height of the cube. Since the object is a cube, the top will be parallel to the base, and hence to the ground-line, so with the aid of the T-square rule in the line A_2C_2. Finally, line in the three *visible* vertical lines.

noting that the projector from D coincides with that from B, and that the "B" line cannot therefore be seen, and hence cannot be drawn except to coincide with that from D.

Now measure down $\frac{1}{2}$ in. from A_2, and through this point draw a line ST at 45°. Suppose that the corner of the cube is to be cut off along this line ST, the line itself being really the elevation of a plane. Set down a projector from T, and find the corresponding line T_1T_2 on the plan. The stippled area AT_1T_2 is the *section* on the line ST.

Exercise 28.—Draw the plan and elevation of a cone standing vertically on its base of 3 in. diameter, its perpendicular height being 4 in.

Draw the line XY as in fig. 39, and fully $1\frac{1}{2}$ in. below this line set along a short horizontal centre line EF. Choose any point O as centre on the latter line, and with radius OA = $\frac{1}{2}$ of 3 in., = $1\frac{1}{2}$ in., draw the circle ABCD, which is the plan of the cone. From A, O, and C set up projectors; those from A and C cut the ground-line at A_1 and C_1. Measure up 4 in. from the ground-line on the projector from the centre O, to get the height of the apex. This point is at O_1. Join A_1O_1 and C_1O_1, and line in the triangle $A_1O_1C_1$, which is now the elevation of the cone.

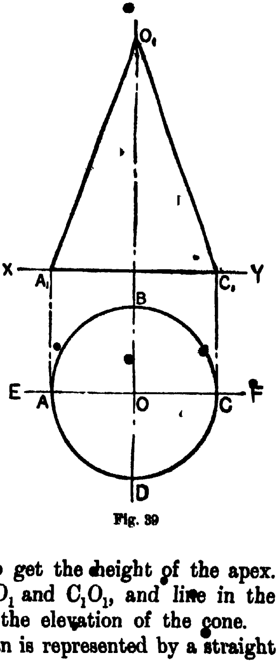

Fig. 39

Note that the circle in the plan is represented by a straight line in the elevation. When any part of an object is circular, the circle should be made first on the drawing, if it is at all possible, and the sizes projected from such circle on to the other views. This method saves time, as one measurement (the setting of the radius on the compasses) may serve for three or more views.

Exercise 29.—Draw the plan and elevation of a square pyramid standing upright on the ground-plane, one of the edges of the base making an angle of 60° with the line XY. The base is 2 in. square, and the vertical height is 4 in.

Draw a light horizontal line XY, see fig. 40, and below it construct the square ABCD, making the angle YEB = 60°. This may be done conveniently by the 60 set-square. Each side of the base is, of course, 2 in., and since the object is a square pyramid, the position of the apex in the plan must be at the intersection of the diagonals. Draw therefore the diagonals AC and BD; these intersect at O, which is the apex on the plan view. The triangular sides of the pyramid slope from the base to the apex, and these sides are indicated in the plan by drawing in the lines OA, OB, OC, and OD.

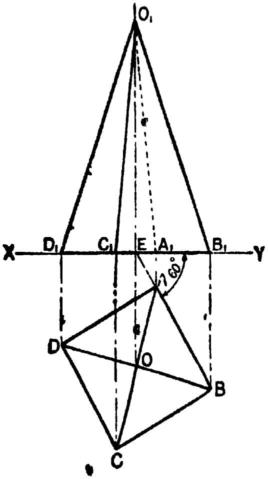

Fig. 40

To obtain the elevation, set up the projectors AA$_1$, BB$_1$, CC$_1$, DD$_1$, and OO$_1$. Measure up 4 in. from the ground-line XY on the projector OO$_1$ in order to obtain the position of the apex. Join O$_1$D$_1$, O$_1$C$_1$, and O$_1$B$_1$ as shown. Since O$_1$A$_1$ is at the back, i.e. hidden from the observer's eye, it is indicated by a dotted line, whereas full lines are used for the other three.

It should be noted that the lengths of the lines in either plans or elevations do not *always* indicate the true lengths of the lines on the object that they represent. In fig. 39 the slant height of the cone is correctly represented by the length of the lines O$_1$A$_1$ or O$_1$C$_1$, but in fig. 40 the slant height of the pyramid is not represented by any of the lines. The reason is that in the case of the cone the lines O$_1$A$_1$ and O$_1$C$_1$ are parallel to the vertical plane, whereas in the case of the square pyramid, not one of the corresponding lines O_1A_1, O_1B_1, O_1C_1, and O_1D_1 is parallel to the vertical plane, but all more or less obliquely placed with regard to it. Occasionally it is necessary to be able to find the true dimensions, and one method of doing so will be exemplified in the following exercise.

EXERCISE 30.—An equilateral triangular prism, 1½-in. side and 4 in. long, rests with one of its rectangular faces on the

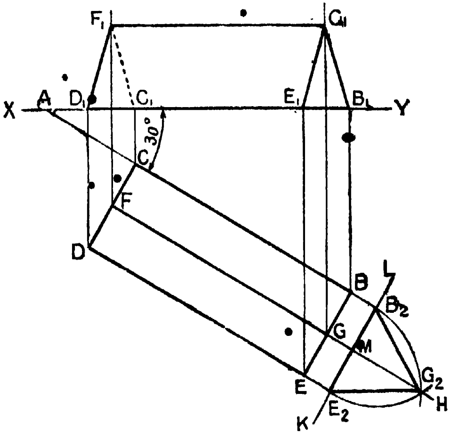

Fig. 41

ground in such a position that its long edges make 30° with the XY line. Draw the plan and elevation.

Draw the XY line, fig. 41, and set off with the aid of the 60 set-square the line AB so that angle YAB = 30°. Cut off CB = 4 in., and on it construct the rectangle BCDE, CD being 1½ in., since each short edge of the prism is 1½ in. long. Bisect CD in F and BE in G. Join FG, this line representing the ridge of the prism. BCFDEG is now the complete plan of the prism.

Set up the projectors DD_1, FF_1, CC_1, &c., as indicated. Once the points on the XY line are obtained it will be found impossible to proceed further with the elevation, because the *true* height of the elevation is not known. The height could, of course, be obtained by calculation (see *Textile Mathematics*, Part I, p. 25); it should be obtained in this case by drawing.

Produce FG to H, making GH greater than 2 in., and draw any line KL at right angles to FH, i.e. parallel to BE, and about ½ in. from it. Draw the projectors BB_2 and EE_2 and join B_2E_2. On B_2E_2 construct an equilateral triangle $B_2E_2G_2$. The distance MG_2 is the true height of the prism, and this dimension should therefore be taken on the dividers.

Set up the distance MG_2 from the ground-line XY, and complete the elevation. Measure the lines D_1F_1, C_1F_1, &c., to prove that they do not show the true dimension of the short sides of the prism, i.e. that they are shorter than 1½ in. At the same time, note that F_1G_1 does not measure the true length of the prism. In both cases the loss is due, as mentioned in connection with fig. 40, to the respective lines not being parallel to the respective planes.

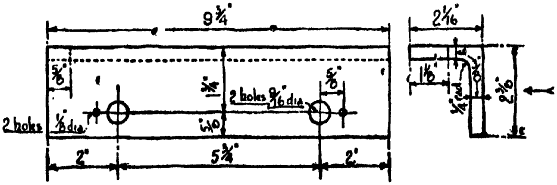

Fig. 42

Exercise 31.—The free-hand sketch in fig. 42 gives particulars of front and end elevations of the lower slide of a roving frame; make complete working drawings from the sketch.

Before commencing with any drawing the student should first look to see if the object is symmetrical about any line, real or imaginary. If it is, as is the case with the shaft in fig. 6, this line should be drawn first, and upon it the drawing should be built, as it were. In fig. 42 there is no such line, and it will probably be found most convenient in this and similar cases to block in the main outlines of each view, filling in the smaller details later.

Draw, therefore, the rectangle ABCD of the front elevation, fig. 43, looking in the direction of the arrow in fig. 42. The total length is 9¾ in., as shown in the front elevation in fig. 42, while its depth is 2⅜ in., indicated at the extreme right of the end elevation in the same figure. If AB, fig. 43, is drawn first, it should be made somewhat longer than necessary, and the required length, 9¾ in., marked off with the aid of a rule. In the same way, AD and BC should be made rather longer than 2⅜ in., and the correct depth then marked off. This method may be made a general practice, as it is far better to have to shorten a line by erasing part of it, than to lengthen the line at a subsequent stage; it is difficult to get the additional length of the same quality and thickness, and in the same straight line, as the original line.

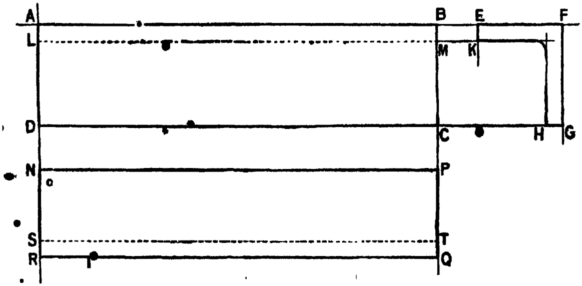

Fig. 43

Now draw the outline of the end elevation, its total depth being projected from the front elevation, while the remainder of the dimensions are obtained from the sketch in fig. 42. The thickness EK, fig. 43, may now be projected from the end elevation to the front elevation, as shown by the dotted line LM; the line is dotted because the edge which it represents must evidently be at the back of the slide, and therefore not visible in the front elevation when viewed as indicated by the arrow in fig. 42.

Next draw in the outline of the plan, NPQR, the length being obtained by projecting down from the front elevation, while the depth PQ is got from the width EF in the end elevation. Take GH on the dividers, and set this dimension up from Q, i.e. the width GH is represented on the plan by the depth QT. The line ST is then drawn dotted. At this stage the drawing will appear as at fig. 43, and it now evidently represents a piece of angle-steel of the section shown in the end elevation $2\frac{1}{16}$ in. × $2\frac{3}{8}$ in. × $\frac{3}{8}$ in., and of the length shown in plan and front elevation, viz. $9\frac{3}{4}$ in.

Measure $\frac{5}{8}$ in. from A, and set down the short dotted line UV shown in fig. 44; by similar methods draw the short full line XY $1\frac{1}{8}$ in. from the left of the end elevation. Set down a projector from UV through the plan. Now, the end elevation being wholly composed of full lines, shows the shape of the left-hand end of the plan and front elevation. FG is the front of the slide, as is also RQ. Take the distance FY on the dividers, and set it up on the plan at RZ. Draw a horizontal line from Z until it meets the projector from UV; the line is horizontal because horizontal dimensions in the end elevation become vertical dimensions in the plan. Evidently the small corner NIJZ is cut out, and this may be proved by assuming the plan to be correct, and testing the correctness of the two elevations.

To complete the three views, it remains only to add the holes indicated in fig. 42 to the front elevation, and to project them into the end elevation and plan as shown in fig. 44.

The last step is to remove all the projectors and other unnecessary lines, and add the various dimensions. Although not absolutely necessary, it will be instructive to draw a section on the plane AA (plan view, fig. 44). Set along the projectors indicated, and obtain the required widths from the end elevation. Next find the centre line of the hole through which the section AA passes, after which the hole itself may be drawn in. The arrows at AA, fig. 44, indicate the direction in which the section is viewed, so that the only dotted lines to be inserted are those for the small dowel-pin hole. Use a 45 set-square to draw in the "section" lines shown in the bottom right-hand corner of fig. 45, and the view is complete.

Fig. 45 shows the complete working drawing of the slide

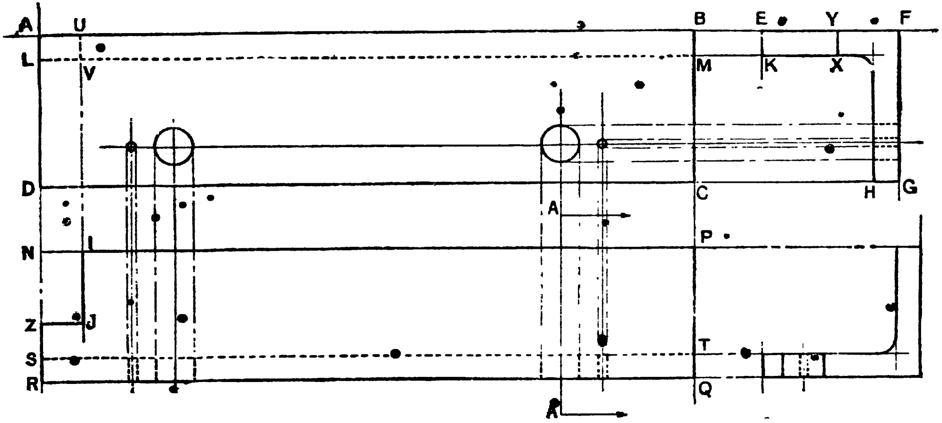

Fig. 44

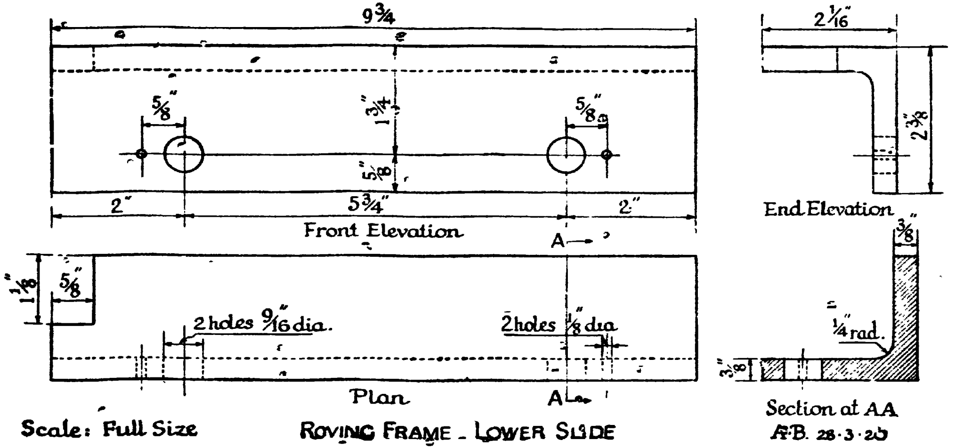
9¾
5/8"
1¾"
5/8"
5/8"
2"
5¾"
2"
Front Elevation
A
2 1/16"
2⅜"
End Elevation
1⅛"
5/8"
2 holes 9/16" dia.
2 holes ⅛" dia
Plan
A
3/8"
¼" rad.
3/8"
Section at AA
A.B. 28·3·25
Scale: Full Size
ROVING FRAME - LOWER SLIDE

Fig. 45

from the sketch, fig. 42, with all the unnecessary lines removed and completely dimensioned. No hard-and-fast rules can be laid down in regard to the dimensioning of drawings. Generally speaking, the dimensions should appear in the most likely places, the student's knowledge of which will develop along with his knowledge of the requirements of the method of manufacture. It should be laid down that, wherever possible, the dimensions should be written so that they may be read either from the bottom or the right-hand side.

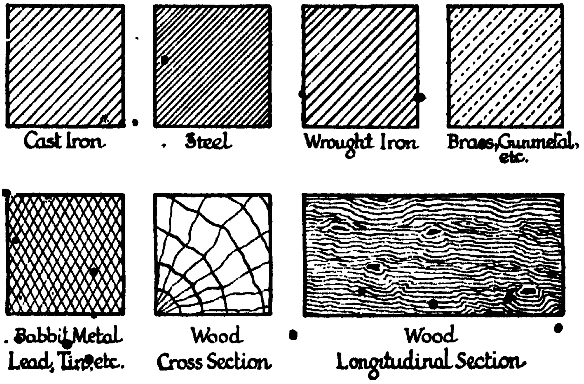

Fig. 46

The student should also make a practice of putting a title to his drawing along with the scale, date, and his initials, all as shown in fig. 45.

It is a general and good practice to cross-hatch or section-line any part of a drawing that does not show an outside surface, and advantage is usually taken to indicate, by different types of section-lining, the nature of the material or materials shown in the cross-section. In elaborate drawings, colours are used as distinguishing mediums.

The nature of these section-lines is conventional, and any required meaning may be attached to them; those shown in fig. 46 are, perhaps, most common.

CHAPTER VI

FASTENINGS: BOLTS, SCREWS, RIVETS, AND KEYS

In textile machinery, as in all other types, the component parts of a particular machine have to be fastened together in ways which are dictated by circumstances; the most common modes are by bolts and nuts, set-screws, rivets, and keys. In the drawing of simple mechanical parts, the actual method of fastening is seldom shown; nevertheless, in a great number of cases, the shape of a part has to be modified to suit a particular kind of fastening. Thus, in fig. 6, provision is made at G and H for two keys; again, in fig. 45, holes are provided for set-screws—sometimes called pinching-screws—and for dowel- or steady-pins. It will be useful, therefore, to take up at this stage the most common methods of fastening parts together.

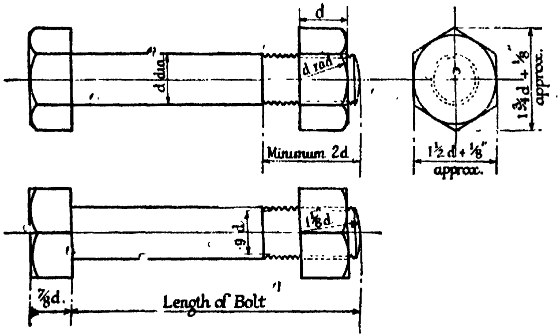

Fig. 47

Bolt and Nut.—Possibly the most common method of fastening parts together is by bolt and nut, one of the principal features of which is the ease with which parts bolted together may be separated when required. Bolts and nuts may be of many different shapes, such shapes being fixed by economic and other circumstances. Unless in exceptional cases, nuts are either square or hexagonal, but greater variety obtains in the shapes of the heads of bolts. Perhaps the most common form is that shown in fig. 47, which illustrates the well-known hexagon-headed bolt and hexagonal nut. The proportions of these bolts are now standardized, as is the form of the screw thread used, and a table showing the various proportions is given on p. 59.

Fig. 47 is a more or less conventional form much used for drawing purposes, and the proportions, while not being strictly accurate, are sufficiently correct for most purposes.

Exercise 32.—With the aid of the data given in fig. 47, make a drawing, full size, of a hexagon-headed bolt, 1 in. diameter × 6 in. long, noting that length is measured from the inside of the head to the extreme end of the bolt.

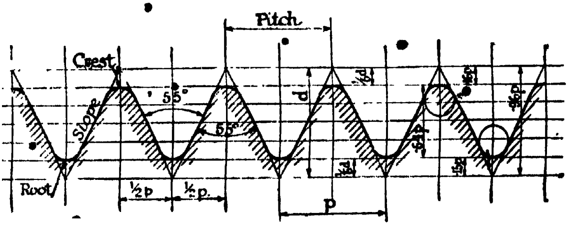

Fig. 48

No difficulty should be experienced in making the above drawing, but it may be worth while pointing out the various methods of drawing the threads of bolts and screws.

Fig. 48 shows the standard Whitworth thread as used in this country, with the proportions and names of its various parts. Since too much time would be occupied in making a proper drawing of every bolt or screw required, conventional methods are employed which imitate, more or less closely, the profile of the thread. Thus, the illustrations at A, B, and C, fig. 49, show three methods of imitating the screw thread. The sketch at A shows the quickest method, and, although it may be a rather poor imitation of a thread, it is, nevertheless, much used, chiefly because of the ease with which it may be drawn, generally freehand, and because it is sufficiently distinctive.

The drawing at B is a development of that at A, and gives a very approximately true representation of the thread. It should only be used where a first-class representation is essential.

The last drawing, C, shows a form which is much used, but it is not nearly so good an imitation of the thread as B, while it takes more time to make it than to make A; hence, taking all things into consideration, the form at A is to be preferred for all general purposes.

EXERCISE 33.—Make full-size views of a Whitworth thread, the pitch of the thread being 1 in. and the proportions as indicated in fig. 48.

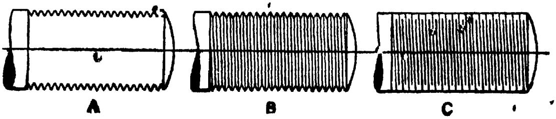

Fig. 49

EXERCISE 34.—Draw a 1-in.-diameter bolt, the screw thread having a pitch of $\frac{1}{8}$ in.; show the three conventional methods of representing the screw, similar to fig. 49.

The following table shows the proportions of standard bolts and nuts, from $\frac{1}{4}$ in. up to 2 in. diameter, this being about the range regularly used in textile work, although larger bolts, up to 6 in. diameter have also been standardized.

All dimensions given are in inches and fractions of an inch.

Fig. 50 shows another common form of bolt, known as a cup- or snap-head bolt; the figure also indicates the usual proportions of such bolts. The bolt differs from that in fig. 47 in two important particulars. The head of the bolt in fig. 50 is spherical in shape, as compared with the hexagon-shaped head in fig. 47, while the neck of the former is square as compared with the round neck of the latter. The function of the square neck in fig 50 is to prevent the bolt from turning round in the hole when the nut is being screwed up, the hole naturally

Diameter of Bolt.	Approx. diameter at bottom of Thread.	Thickness of Nut.	Thickness of Bolt Head.	Width across Flats.	Width across Corners.	Threads per inch.	Pitch of Thread.
3/16	9/64	3/16	5/32	7/16	33/64	24	·041
1/4	3/16	1/4	7/32	33/64	39/64	20	·05
5/16	1/4	5/16	17/64	39/64	11/16	18	·055
3/8	19/64	3/8	21/64	45/64	13/16	16	·0625
1/2	13/32	1/2	7/16	29/32	1 1/16	12	·083
5/8	33/64	5/8	35/64	1 3/32	1 17/64	11	·091
3/4	5/8	3/4	21/32	1 19/64	1 1/2	10	·1
7/8	47/64	7/8	49/64	1 31/64	1 45/64	9	·111
1	27/32	1	7/8	1 43/64	1 61/64	8	·125
1 1/8	61/64	1 1/8	63/64	1 55/64	2 5/32	7	·143
1 1/4	1 1/16	1 1/4	1 3/32	2 3/64	2 23/64	7	·143
1 3/8	1 11/64	1 3/8	1 13/64	2 7/32	2 35/64	6	·167
1 1/2	1 19/64	1 1/2	1 5/16	2 13/32	2 25/32	6	·167
1 5/8	1 3/8	1 5/8	1 27/64	2 37/64	2 31/32	5	·2
1 3/4	1 1/2	1 3/4	1 17/32	2 3/4	3 3/16	5	·2
1 7/8	1 19/32	1 7/8	1 41/64	3 1/32	3 31/64	4 1/2	·222
2	1 23/32	2	1 3/4	3 5/32	3 5/8	4 1/2	·222

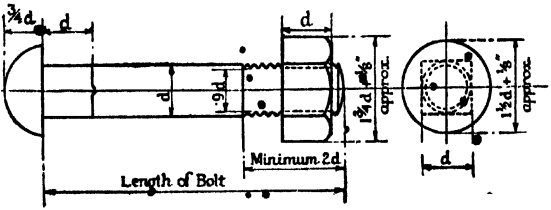

Fig. 50

being made square to correspond, or else rectangular to allow of adjustment. As square and rectangular holes are more difficult to machine than round holes, such bolts are only used when the rectangular holes are cored out, i.e. formed in the casting process.

EXERCISE 35.—Use the proportions given in fig 50, obtain all further information from the table on p. 59, and draw the front and end elevations of a cup-headed bolt ¾ in. diameter × 5 in. long.

A third useful form of bolt is that shown in fig. 51, its distinguishing feature being the square head. Common proportions are indicated in the figure, and these may be used as the basis of a further exercise.

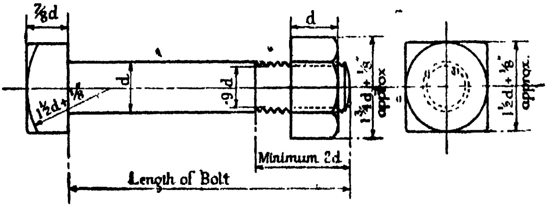

Fig. 51

EXERCISE 36.—Using the proportions given in fig. 51, and obtaining all other necessary particulars from the standard table on p. 59, draw front and end elevations of a square-headed bolt, 1¼ in. diameter × 8 in. long.

Many other forms of bolt will be found in practice, but the above three are probably the most important. It may be pointed out that bolts such as those illustrated in figs. 47, 50, and 51 may be briefly described as under:

Fig. 47.—Bolt—Hex. Rd. Hex., 1 in. diameter × 6 in. long.
Fig. 50.— „ Cup. Sq. Hex., ¾ in. „ × 5 in. „
Fig. 51.— „ Sq. Rd. Hex., 1¼ in. „ × 8 in. „

In the above descriptive phrases, e.g. Hex. Rd. Hex.; the first abbreviated word stands for the head of the bolt, the second for the neck, and the third for the nut; the method is perfectly general.

Nuts are usually of the form shown in Figs. 47, 50, and 51;

but square nuts are occasionally used, in which case their dimensions are similar to the square-headed bolt. The thickness of nuts, unless for special cases, equals the diameter of the bolt.

Where any part of a machine or the like is subject to shock or vibration, additional nuts are put on the bolt for the sake of security. Such nuts are known as "lock-nuts" or "jamb-nuts". They are similar to ordinary nuts in all respects except that they are not so thick; the usual thickness is two-thirds of that of the ordinary nut.

Where the bolts have to be screwed up against surfaces which are not machined, it is a regular practice to make use of washers. These useful articles are usually plain circular rings, but some are made with a bevelled edge. The usual proportions of washers are: outside diameter = 2⅛ bolt diameter, and thickness = ⅛ bolt diameter, but practice is irregular.

Screws.—As in the case of bolts, screws are of many and varied forms, and fig. 52 shows the leading features and proportions of six of the most largely used kinds. Bolts are generally employed in the fixing together of the gables, rails, and heavy brackets of a machine, whereas screws are used to hold all the smaller and lighter parts in position; the chief difference in their application is that in place of using a nut with a bolt, holes must be tapped in the part to receive the thread of the screw. Another point of difference, although this is not universal, is that the thread of a screw generally extends up to the head.

In fig. 52, A represents the most common form; it is a hexagon-headed screw, and is made in all dimensions from ½ in. diameter upwards. The screw at B is the square-headed type, and is made in all sizes from ⅜ in. diameter downwards. Illustration C shows the countersunk-head form; this is used only where there is no room for a head to project above the surface. It is screwed home with the aid of a screw-driver in place of a spanner, which is used for types A and B. The examples exhibited at D and E are cup- or round-head and cheese-head or fillister respectively, and are screwed up with a screw-driver; such screws are usually of small dimensions as repeated use of the screw-driver tends to spoil the shape of

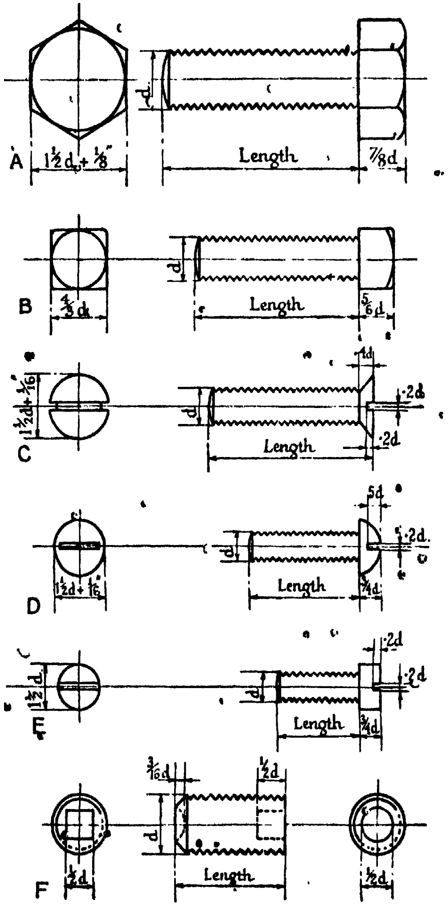
A
1½d + ⅛"
d
Length
⅞d
B
4/3 d
d
Length
5/6 d
C
1½d + 1/16"
·1d
d
·2d
Length
·2d
D
1½d + 1/16"
·5d
d
·2d.
Length
¾d
E
1½d.
·2d
d
·2d
Length
¾d
F
3/16 d
½d
d
Length
½d
½d

Fig. 52

the slot in the head. The drawing at F shows one form of what is termed a grub-screw, this particular variety being much used in collars and similar objects, and having a hardened hollow point. It is screwed home by inserting a square key in the square hole provided for the purpose.

EXERCISE 37.—Using the dimensions given in fig. 52, draw two views of each kind of screw illustrated to the following leading dimensions:—

A: $\frac{5}{8}$ in. diam. × 4 in. long, length measured from inside of head.
B: $\frac{3}{8}$,, × 3 ,, length measured from inside of head.
C: $\frac{5}{16}$,, × $1\frac{1}{2}$,, length measured over all.
D: $\frac{5}{16}$,, × 1 ,, length measured from inside of head.
E: $\frac{1}{4}$,, × $\frac{3}{4}$,, length measured from inside of head.
F: $\frac{3}{8}$,, × $\frac{3}{4}$,, length measured over all.

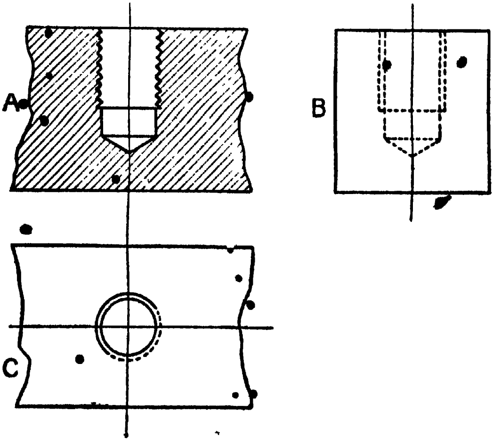

Fig. 53

Fig. 53 shows the method of representing a hole tapped to receive a screw; A is a sectional elevation, B an outside elevation, and C a plan.

EXERCISE 38.—Draw three views of a hole tapped to receive a screw ¾ in. diam. × 1½ in. deep, with ¼ in. clearance for the tap; make the angle at the point of the drill approximately 120°, and the views similar to those shown in fig. 53.

Rivets.—When two or more parts are to be rigidly fixed together, there being no necessity for their ever being taken apart, or where absolute rigidity is essential, rivets are usually employed.

Rivets are of many different forms, such forms depending upon the positions in which the rivets are to be placed, and fig. 54 illustrates four of the principal kinds; the proportions mentioned on the drawings are approximately correct, and sufficiently so for all general drawing purposes.

Illustration A shows what is known as the half-countersunk or raised head, while that at B is the well-known cup- or snap-head. The drawing at C shows a pan-head rivet, with the riveted part shaped roughly like a cone by the hammer. The same form of rivet appears at D, but here the riveted part is hammered into a countersunk hole, and the projecting part then chipped off, or filed flush with the plate or frame. Simple pins are occasionally used as rivets, in which case both ends are hammered into countersunk holes, or shaped into heads somewhat like A in fig. 54.

EXERCISE 39.—Draw full-size views of the various forms of rivets shown in fig. 54, making A 1 in. diameter; and B ¾ in. diameter; C ⅝ in. diameter; and D ½ in. diameter. In each case, calculate the dimensions not given to the nearest $\frac{1}{64}$ in., and assume reasonable thicknesses of plates.

It might be mentioned that to form a head similar to that shown at A, the length of the rivet should project from the hole about 1 diameter, for B, 1¼ diameters; for C, 1½ diameters; and for D, ¾ diameter.

Keys.—Where two parts, such as a gear-wheel mounted on a shaft, have to be fixed so as to prevent one from rotating round the other, some form of key is, in general, used. Keys, like all other means of fastening, may assume many different forms, but the principal types are four in number, and each is represented in fig. 55. In this figure, A is a sectional view of a key variously known as a hollow, saddle, or friction key. It is slightly tapered in its length, say about ⅛ in. per foot, and holds by friction; it is used only for comparatively light drives. Pulleys or riggers for driving machines are almost invariably fixed to line shafts by such keys, which possess the

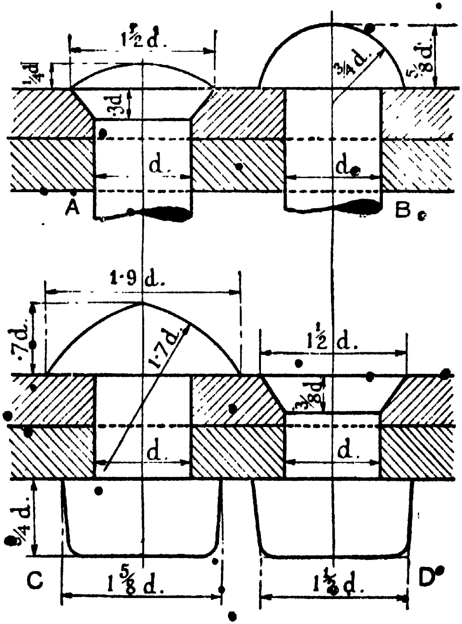

Fig 54

advantage of being readily adjusted along the shaft, because no key-seat or key-bed is required.

Illustration B shows another common form known as a flat key; it is fitted into a key-way in the wheel, and rests on a flat filed or milled on the shaft. It is a stronger form than A, and possesses the advantage of being comparatively easily fitted, but it is not such a satisfactory form as that shown at C: the latter represents a sunk key. When absolute rigidity is required, this form is always used, and the key is fitted into a key-bed milled in the shaft.

In certain cases, such as in clutches, the wheel or other part must not only be made to rotate with the shaft, but must also be free to move along the shaft. In such a case, feather-keys, generally square in section, as shown at D, fig. 55, are used, and are screwed or otherwise fixed to the shaft or to the clutch.

Illustrations E and F show plans and elevations of the two commonest forms of key; E is a plain key, while F is a gib-headed key, and the latter is used where difficulty is found in getting at the point of the key in order to effect its removal.

Keys, like bolts and nuts, &c., are now completely standardized, but common proportions are indicated in fig. 55, while the table below gives a suggested range of keys suitable for most classes of textile work.

PROPORTIONS OF KEYS

Diameter of Shaft.	Width of Key.	SUNK KEYS.			FLAT AND SADDLE KEYS.
		Thickness.	Depth in Shaft.	Depth in Boss.	Thickness.
D.	W.	T.	Ds.	Db.	T.
1	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{5}{32}$
$1\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{32}$	$\frac{5}{32}$	$\frac{7}{32}$
2	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{5}{32}$	$\frac{7}{32}$	$\frac{9}{32}$
$2\frac{1}{2}$	$\frac{5}{8}$	$\frac{7}{16}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$
3	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{7}{32}$	$\frac{9}{32}$	$\frac{3}{8}$
$3\frac{1}{2}$	$\frac{7}{8}$	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{7}{16}$
4	1	$\frac{11}{16}$	$\frac{9}{32}$	$\frac{13}{32}$	$\frac{1}{2}$
5	$1\frac{1}{4}$	$\frac{13}{16}$	$\frac{5}{16}$	$\frac{1}{2}$	$\frac{9}{16}$
6	$1\frac{1}{2}$	1	$\frac{3}{8}$	$\frac{5}{8}$	$\frac{5}{8}$

All dimensions are given in inches and fractions of an inch.

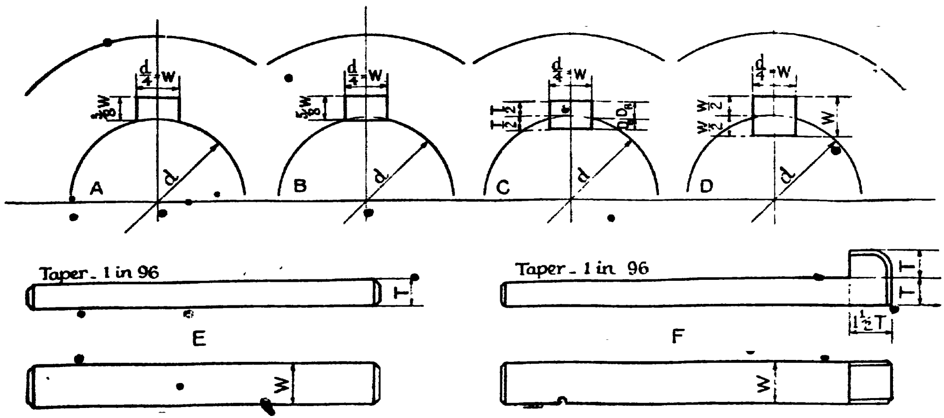
$\frac{d}{4}=W$
$\frac{5}{8}W$
$\frac{T}{2}$
$\frac{D}{8}$
$\frac{W}{2}$
W
d
A
B
C
D
Taper - 1 in 96
T
E
W
F
$1\frac{1}{2}T$

Fig. 55

For intermediate diameters use the key given for the next larger diameter. The taper is $\frac{1}{8}$ in. per foot, i.e. 1 in 96. The dimensions given are measured at the large end of the key. To transmit the full power of the shaft, a condition that has not often to be fulfilled in textile work, the length of the key should not be less than $1\frac{1}{2}$ times the diameter of the shaft.

EXERCISE 40.—With the information given in fig. 55, and in the table, draw plan, and front and end elevations of a plain key 5 in. long and suitable for a 2-in.-diameter shaft. Also draw a gib-headed key, 6 in. long, suitable for a 3-in.-diameter shaft.

EXERCISE 41.—Draw sections of the four forms of key shown in fig. 55, suitable for a 5-in.-diameter shaft.

CHAPTER VII

SKETCHING AND DRAWING OF DETAILS

Proficiency in the sketching of machine details can only be obtained by practice, but the following remarks and exercises may be of benefit to the untrained student.

Freehand sketches of parts of machines may be made, either complete in themselves or preparatory to the making of full working drawings. In the former case the sketches must be made to represent as closely as possible a finished working drawing, practically the only difference being the unavoidable variation in the truth and quality of the various lines. In the latter case, some experience is needed in order to pick out the most characteristic views, that is, the views that will most readily exhibit the details of form, and, consequently, the various dimensions. In regard to rough sketches of this kind, it will be understood that marginal and other notes, as well as brief written descriptions, are permissible.

In choosing suitable views, regard should be paid to the final or working position of the part in the machine, so that such part may appear in the drawing just as it appears in the machine. Views of parts which are not usually seen should only be drawn for particular and definite reasons. Again, as previously pointed out, in the case of parts made from bar metal—plain pins, studs, shafts, &c.—one view only is necessary, as the word "diameter", or some other suitable word or words, indicating the section, may be used along with the appropriate dimensions.

The dimensioning of a drawing appears at first sight a rather simple operation, but the proper dimensioning of a drawing is just as important as the proper size and position of the lines which form it. The student would do well to acquire the habit of questioning the usefulness of each dimension he is prompted to put upon paper. If the size can be done without, or if one size can be made to take the place of two, or if the sum of two or more sizes is more important than its individual components, appropriate steps should at once be taken to record the most useful.

In dimensioning parts which are long in comparison with their other dimensions, care should be taken, when measuring up individual dimensions, to see that their sum coincides with the overall dimension. This overall dimension should be placed immediately below the line of individual sizes, as shown in the example in fig. 59. In certain cases it is necessary to choose some line, either on the object or outside the drawing altogether, as a datum line, to which all the important dimensions may be referred, see fig. 76.

It should be remembered that a knowledge of the actual manufacture of a part is the best guide to its proper dimensioning. In the case of certain parts, such as castings, individual details may pass through all or any of the hands of a patternmaker, planer, shaper, turner, fitter, &c., each of whom uses only particular groups of sizes. Certain sizes are, of course, used by everybody concerned, but certain other sizes are of no use except to a particular class of workmen. In the case of these latter sizes, so far as it is possible, each class of sizes should be kept distinct from the others, e.g. the fitter's sizes should be kept apart from the turner's sizes, either by putting them on different views, or by putting one set above, and another set below, a particular view. It is recognized that, in many cases, this is a difficult thing to do, but, if the principle is kept in mind, the results will be of benefit to all who have occasion to use the drawings.

The remainder of this section is devoted to providing the students with examples of sketches and working drawings. Whenever possible, however, the student should endeavour to secure actual parts, and make from them the sketches and drawings required. For this part of his work it would be wise to be provided with a pair of 4-in. outside callipers, a corresponding pair of inside callipers, and a small pocket square, as well as a 12-in. steel straight-edge. A plumb-line is also useful if a stable vertical datum line is difficult to introduce.

Ratchet-retaining Pawl.—Fig. 56 is a dimensioned sketch giving two elevational views of a certain type of retaining pawl for the ratchet-wheel in the positive uptake (take-up) motion of a loom. The catch or pawl is pivoted or fulcrummed on a stud which passes through the hole in boss A; the stud is fixed to the end gable or frame of the loom. The point B is shaped to fit in between the teeth of the ratchet-wheel, while a handle C is provided to enable the operator to disengage at will the point B from the teeth of the ratchet.

EXERCISE 42.—From the dimensioned sketch given in fig. 56, make complete working drawings of the ratchet-retaining pawl, front and end elevations and plan.

Possibly the first difficulty that will confront the beginner is the spacing of the three views required according to the size of the paper at his disposal. To help him in this, it is a good plan to construct block outlines of each view, such block outline being simply the smallest rectangle that will completely enclose the view. A brief inspection of the front elevation in fig. 56 will show that it could be enclosed in a rectangle 6 in. + $\frac{3}{4}$ in. = 6$\frac{3}{4}$ in. wide, and 3$\frac{1}{4}$ in. + 3$\frac{1}{2}$ in. + 3$\frac{1}{2}$ in. = 10$\frac{1}{4}$ in. high. Similarly, the end elevation could be enclosed in a rectangle 2$\frac{1}{16}$ in. wide and 10$\frac{1}{4}$ in. high. The plan, usually drawn below the front elevation, will thus be 6$\frac{3}{4}$ in. wide by 2$\frac{1}{16}$ in. high. It now becomes a comparatively easy matter to ascertain just how much space will be occupied by the actual drawings, and how much can be conveniently left to maintain proper spacing of the various views.

When the desired spacing has been fixed, the actual drawing can be commenced by putting in the horizontal and vertical centre lines which pass through the hole on which the pawl is fulcrummed. The student should work round these two centre lines as far as possible, and attempt to complete the two elevations.

It will be found impossible to complete these views until the plan has been drawn. Therefore, project down the vertical line, and cross it by a second horizontal centre line upon which the plan should be built. The drawing of the plan will enable such lines as that at D, fig 57, to be drawn the correct length, and thereafter the three views may be completed, each by reference to the two others, to see that all are in agreement.

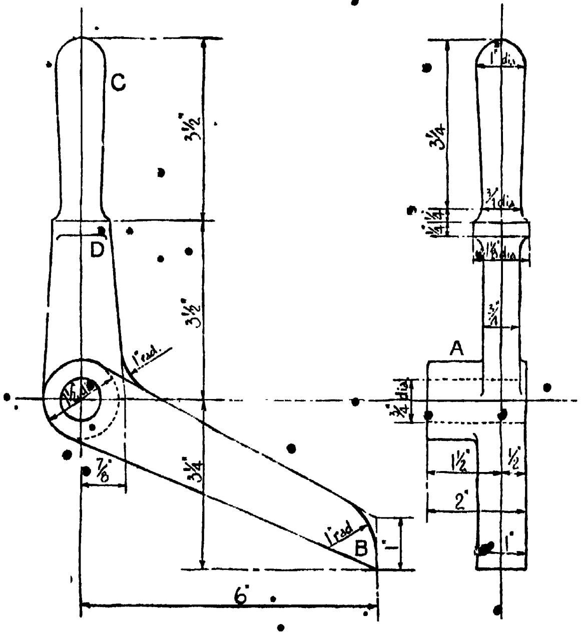

Fig. 56

The lines in a drawing really represent the boundaries or the intersections of surfaces, and if this is kept in mind, "unclosed" areas will never be found. Occasionally, however, two or more separate surfaces will merge into one, and no

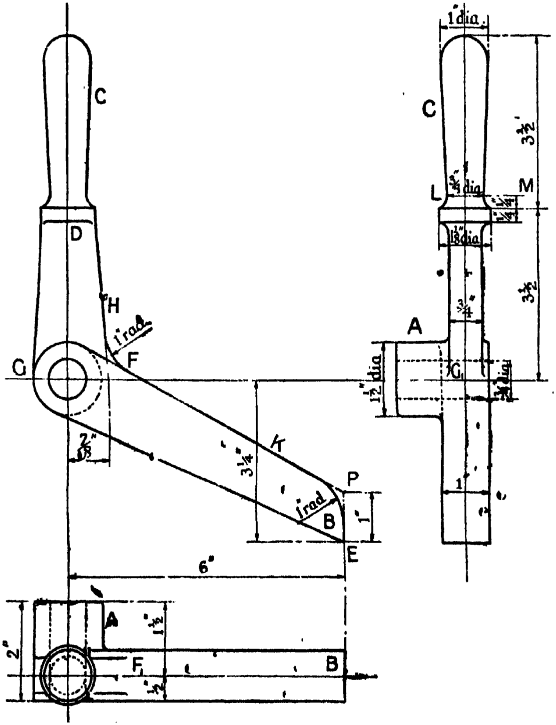

Fig. 57

line can be drawn to indicate this condition, since there is neither a boundary nor an intersection to be represented. Cases of this occur at F and G in fig. 57, and the method of representing the surfaces is indicated at F_1 and G_1, the exact length of the line being obtained by projection, and the actual merging of the surfaces being indicated by the little tapering curves at the extremities of the lines.

Lines which are inclined to the main centre lines are sometimes difficult to locate and dimension; the example worked out in fig. 57 shows three common methods of locating such lines. The side H of the handle lies at a different slope from the other side, which is tangential to the boss. If the side H were continued, however, it would cut the horizontal centre line at a point $\frac{7}{8}$ in. from the vertical centre line, and the location of this point enables the side to be drawn in at the proper slope. Then the handle C tapers from 1 in. diameter to $\frac{3}{4}$ in. diameter, the latter or smaller dimension being given as $\frac{1}{4}$ in. from the bottom. No line would actually appear on the handle at this part, and the dimension line at L is continued as a locating line to M, so that there may be no dubiety as to the position of the smallest diameter. Again, the surface K is tangential to the boss, and if continued would meet a perpendicular from E 1 in. above E. This fact is shown at P, and the drawing of the chain-dotted line will enable the line indicating surface K to be correctly drawn.

In the actual measuring of parts, it is not always an easy matter to obtain the correct dimensions of radii. Paper or cardboard templates may be made to fit, after which the construction shown in Exercise 14 may be used to find the radius. In this connection, gauges of common radii can be made from thin sheet-metal and stamped with their sizes, and it is sometimes useful to remember that a halfpenny is 1 in. diameter, and can thus be fitted to a $\frac{1}{2}$-in. radius.

Rough sketches, such as that illustrated in fig. 56, are often made in a hurry, with little thought of arranging the dimensions to the best advantage, since this can best be done when the requisite views have been properly drawn in proportion. Fig. 56 shows one method of dimensioning the ratchet pawl under consideration, but it is believed that the method shown in fig. 57 will be found more acceptable, as it bears out, as far as applicable, the principles stated at the beginning of this chapter.

Shuttle-box Front.—Fig. 58 gives three views of a shuttle-box front as used in a heavy loom. It is screwed to the lay of the loom by screws which pass through the slots A; the slots are used to allow of adjustment, and, as the name of the part implies, it serves as a front to the shuttle-box. The inner face, i.e. that against which the shuttle bears, is made sloped, so that it prevents the shuttle from lifting, while the groove along this same face prevents the weft yarn from being trapped between the shuttle and the box front; there is a corresponding groove in the front of the shuttle in line with the shuttle eye. The box front is made of malleable cast iron, the malleability being almost a necessity because of the incessant shock to which the part is subjected. At the same time, the fact that the part is of malleable cast iron permits the use of a comparatively light section.

EXERCISE 43.—Using the information given in fig. 58, draw front elevation, plan, and end section of the shuttle-box front illustrated.

In this example there are no outstanding centre lines upon which the various views may be built. The part is undoubtedly symmetrical about a vertical centre line drawn through the front elevation or plan, but such a centre line would not prove very useful in the actual making of the drawing. Possibly the best method would be to draw the base line BC of the front elevation, and use it as the basis on which to build up the front elevation. Draw in, therefore, as much as possible of the outline of the front elevation, and add the screw-slot patches and the base.

Since the drawing is very long in comparison with its breadth and depth, and since its central part shows no variation from its regular section, it will be found economical, both in regard to time and space, if the object is shown "broken". This method is perfectly general, and all long parts of regular section may be thus depicted. It is a good practice to draw the "breaks" to imitate in a rough kind of manner the actual shape of the section through which the break occurs. This is exemplified at D and E.

When the outline of the front elevation is drawn in, it will be found necessary to draw in the end section, assumed to be taken across the plane FF. The section can be completed

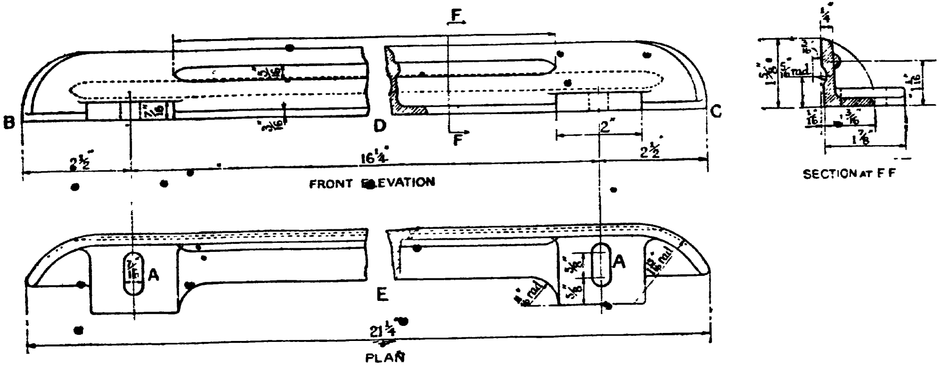
F
F
B
D
C
7/16"
3/16"
5/16"
2"
2 1/2"
16 1/4"
2 1/2"
FRONT ELEVATION
A
A
E
7/16"
5/16"
5/8"
1/8" rad
1/8" rad
21 1/4"
PLAN
1/4"
3/16"
5/16" rad
1 5/16"
1/16"
1 3/16"
1 7/8"
7/16"
SECTION AT F F

Fig. 58

except for the dotted lines indicating the screw-slots. Thereafter, the plan should be drawn, all lengths being obtained, as far as possible, by projection from the front elevation, and all depths from the corresponding dimensions in the end section.

At this stage the main outlines of each view will be practically complete, and each view should now be worked up as much as possible by comparison with the two others, until finally all three are complete and in agreement with each other.

Fig. 58 represents a case where a sectional view is more useful than an end elevation, but the student will find it instructive to add an end elevation, projected either from the front elevation or from the plan.

Spinning-frame Spindle.—Fig. 59 shows a front elevation of a 4-in. throstle or flyer spinning-frame spindle, such as is used in the filling of a 4 in. × 2¼ in. or 4 in. × 2⅝ in. bobbin. The flyer, which puts the twist on the yarn, is screwed on to the threaded part

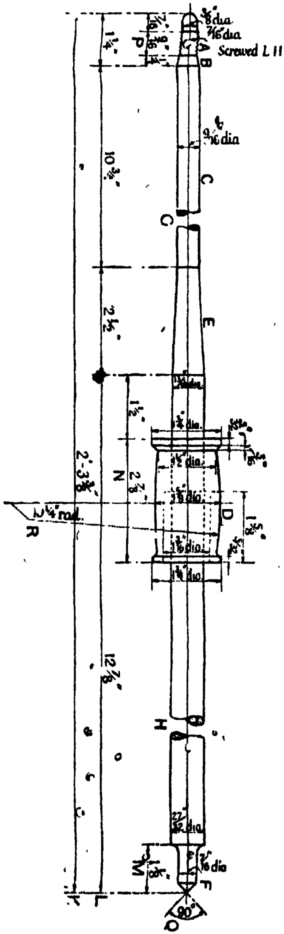

Fig. 59.

A, and centred on the conical or tapered part B; the thread of the screw is left-hand, i.e. opposed to the normal direction, so that when the spindle revolves the flyer will not be unscrewed and thrown off. As the yarn is being wound on the bobbin, the latter is traversed up and down the parallel portion C, most of which is omitted in the drawing. The spindle is driven by a flat tape, web, or list running on the wharve, wherve, or whorl, D, which is forced tightly on the spindle. The spindle is supported in the machine by a neck-brass shaped to fit the conical part E, and by a foot-step at the toe or point F.

EXERCISE 44.—Using the information given in fig. 59, draw the front elevation of the 4 in. spinning-frame spindle illustrated.

This part provides an example of drawing where one view only is necessary; it will be noted that the solidity of the section is indicated by the word diameter, abbreviated to dia., after the particular dimensions concerned. It also provides an example of a long object being "broken", in this case into three parts, so as to economize space and time; the breaks shown at G and H indicate the usual conventional method of representing circular sections. The drawing further illustrates an exception to the general rule stated above, that a part should be drawn in its "natural" position, i.e. as it appears in the machine. In the spinning-frame the spindle stands vertically resting on its point or toe F; it was drawn in a horizontal position simply because it is more convenient to draw straight lines accurately with the aid of the T-square alone, than to draw long vertical lines with the aid of the T-square and set-square; it is illustrated vertically for convenience of page.

For the sake of experience, the student should project an end elevation; he will find it merely a series of concentric circles, and will see that it is of little practical value.

As regards the dimensioning of the spindle, the various sizes have been arranged according to their relative importance. The overall dimension at K is simply a check on the line of sizes at L, these sizes being of first-class importance. The smaller lines of sizes at M, N, and P are of secondary importance, and hence are indicated as shown.

There are two methods of dimensioning worth special mention, viz., those at Q and R. In the former place the angle of the toe could not very well be written inside the drawing, since the space is too small, so the opposite angle is drawn and dimensioned as indicated, the method being based on Euclid I, 15, which proves the two angles concerned to be equal. In the case at R, the given radius is very large, and if the dimension line were drawn to the proper point, there would be a certain waste of space. So the upper part of the line is drawn towards the actual centre, but is stopped short and diverted into the centre line, the actual radius being marked. The whole device is easily read as 10¼ in. radius, struck from a point on the vertical centre line which passes through the middle part of the spindle whorl.

Belt-fork Boss.—Fig. 60 shows, in front and end elevation, the boss of a belt fork such as is used on a card or similar heavy machine. The forks which actually control the belt are bolted to the projecting tongues A and B, and kept from swivelling on the single bolts by being fitted to the V-shaped projections at C. A cast-iron screw, with a specially shaped thread, passes through the central hole D, this hole being swelled or cored out at E in the casting process in order to economize machining time. A small pin, the upper end of which fits into the thread of the screw, is pushed into the small hole F, and is kept in position by a long guide-pin which passes through the hole G; the main function of this guide-pin, as its name implies, is to guide the fork whilst it is traversing; it also serves to prevent the belt fork from rotating round the central screw. The screw itself is turned by a hand-wheel, and as it is revolved, the belt fork, and consequently the belt, can be moved from the fast pulley to the loose pulley, and vice versa. The advantage of using a screw is that the running belt cannot itself move the fork, hence all risk of injury to the operative, or damage to the machine or material, due to the accidental stoppage or starting of the machine, is obviated.

Exercise 45.—Use the information given in fig. 60, and draw front and end elevations of the belt-fork boss.

It will be found best to draw the end elevation first and to project all heights and horizontal centres from it to the front elevation. These two views are all that are absolutely necessary, but the student will find it instructive to make the following further views of the boss:—

Exercise 46.—Make a plan view projected from the front elevation.

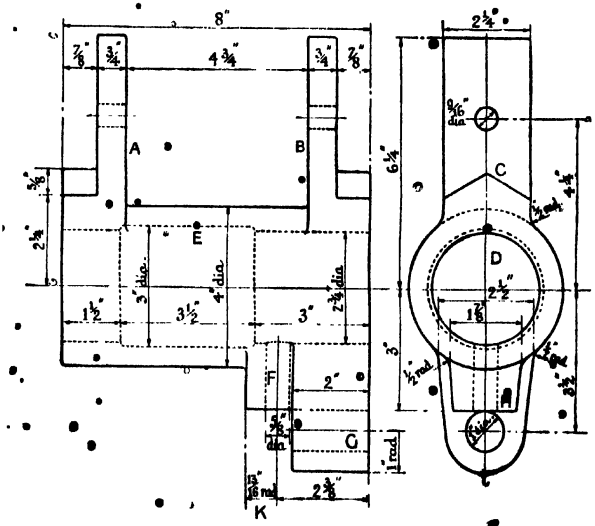

Fig. 60

Exercise 47.—Draw a section through the front elevation on the horizontal centre line.

Exercise 48.—Draw a section through the end elevation on the vertical centre line.

A feature worthy of some slight attention is the dimensioning of the boss H, fig. 60. Neither of the two views in this figure exhibits what might be regarded as its characteristic shape; its true shape, however, is indicated by the dimension at K, viz. $\frac{13}{16}$ in. rad. This illustrates, in some degree, the importance of *naming* a dimension wherever possible; in fact, it may be laid down as a general rule that, if a dimension is a radius, or a diameter, or a square, &c., the fact should be stated on the particular dimension. Thus, in fig. 60 are found such dimensions as 4 in. dia., not merely 4 in., and $\frac{13}{16}$ in. rad., not $\frac{13}{16}$ in. only. If this practice is not carried out, ambiguity might arise in many cases, and another view be necessary in order to remove any doubts.

Another common practice, which has many reasons to commend it, is illustrated in fig. 60. If the figure is carefully examined, extremely few sharp corners will be found. For one thing, it is difficult to get a perfectly sharp corner on a casting, and it is therefore usual to make rounded edges. Another reason is that only in few cases are sharp corners actually necessary, and then they are almost invariably obtained by machining. A third reason is that all the parts of a machine have at some time or other to be handled, and it is a good practice, therefore, to round off all unnecessary sharp corners so that the object may be as pleasant to handle, and as pleasing to the eye, as possible. In the actual drawing, there is no need to use compasses to obtain these little curves; it is sufficient to run them in freehand when lining-in or inking-in the finished drawing.

Where the radii are comparatively large, or where any special importance is attached, the dimension should be particularly stated. In this connection, the student will probably have already seen that the geometrical construction to obtain the centre of a radius is not always necessary, and that the required centres may, after a little practice, be readily found by trial.

With regard to the lining-in or inking-in of a finished pencil drawing, it will be found best to line-in circles first, arcs of circles next, and the straight lines last; the reason for this procedure is that it is much more conducive to good work to join up two circles or arcs by means of straight lines than to join up straight lines by means of arcs or circles.

Protector-rod Lever.—Fig. 61 gives two elevations and a plan of one form of protector-rod lever such as is used in a canvas loom. In fast reed looms there is a danger of the shuttle being trapped in the shed, and, to obviate the breakage of warp threads in such a contingency, such looms are fitted with protector motions. The lever illustrated receives motion from the shuttle, as the latter, when entering the box, causes the swell in the back of the shuttle-box to bear against the surface A; the lever A is bolted through the square hole B on to a square neck formed on the end of the protector-rod. The protector-rod has two flat projecting tongues which point towards two buffers, knees, or frogs, supported by the gables. If the shuttle enters the box in time, the swell is pushed back,

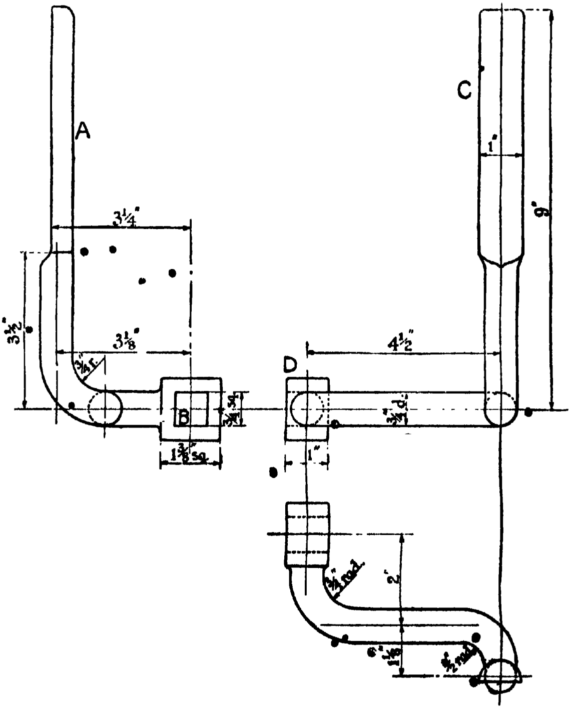

Fig. 61

and in turn the latter pushes back the part A, and causes the protector-rod to rotate through a small angle; sufficient movement is given to allow the projecting tongues to rise above the buffers or frogs. Should the shuttle fail to enter the box in time, the lever A remains in its normal position—to effect which springs are generally used—the tongues strike the frogs, and through suitable connections between one of the buffers and the belt fork, the loom is instantly stopped.

EXERCISE 49.—Draw front and end elevations and plan of the protector-rod illustrated in fig. 61.

It will be found best to take horizontal and vertical centre lines through the hole B, and use them as the basis on which to build the end elevation. This elevation should be completed as far as possible, after which all three views may be advantageously worked up together. The various twists or sets on this part render it imperative to work carefully to the different horizontal and vertical centre lines shown, and all of these should be drawn in at an early stage.

The particular lever shown is for the right-hand end of the loom—that end on the right hand when facing the lay or slay. It will be obvious that a similar part will be required for the opposite end, i.e., the left-hand end. The sole difference in the two parts, so far as the drawing is concerned, is that the lever C, which is 4½ in. centre to centre to the right of the square boss D, would appear at a corresponding distance to the left of the boss D, and the plan would naturally be made to correspond. Cases similar to this occur very frequently in textile machinery, and it is found unnecessary to draw out both kinds; it is sufficient to distinguish between the two parts by proper designation. Commonly, such parts are spoken of as right hand and left hand, but it will be found better to name such parts as "Protector-rod Lever—one hand—as drawn," and "Protector-rod Lever—opposite hand to drawing". The terms right hand and left hand should be reserved exclusively for reference to the "hand" of the machine. In general, the "hand" of a machine is determined by reference to the side on which the driving pulleys are placed when looking on the delivery side. Thus, in the case of a loom, the machine is termed right hand when the pulleys are seen on the right-hand side by an observer looking on the cloth roller or lay, or when the belt control or set-on handle is most conveniently operated by the right hand.

EXERCISE 50.—For further experience the student should draw three views of a lever opposite hand to that shown in fig. 61, after which the two drawings may be conveniently compared. He will see that they are exact mirror images of each other, and will be better able to understand why the second set of drawings need not, unless in very exceptional circumstances, be drawn.

Faller Reception Lever.—Fig. 62 illustrates, in front and end elevations, a faller reception lever or tappet, such as is used in spiral or screw-gill drawing and roving machinery, for the purpose of lowering the bars or fallers from the upper to the lower slides. A small eccentric or cam operates directly on the surface A, causing the whole lever to oscillate about its horizontal centre line BC, and thus force the surface D to rise and fall rapidly. At its upper position surface D receives the dropping fallers from the upper slides and screws, and in its downward movement lays them on the lower slides; the fallers are caught here and moved backward by the lower screws.

EXERCISE 51.—Draw the two elevations of the faller reception lever as illustrated in fig. 62.

The drawing should be commenced by putting in the main horizontal centre line BC and the vertical centre line of the end elevation. The student should then draw as much of the end elevation as possible, after which all the length dimensions of the front may be lightly drawn in, and this latter view completed as far as possible by projection from the end elevation. Finally, the two partly finished views should be worked up together until they correspond in every detail, and the dimensions added to complete the drawing in the usual way.

These two views only are necessary, as they exhibit the complete shape and all the required dimensions, but for practice a further drawing may be made.

EXERCISE 52.—Project a plan from the front elevation of fig. 62, remembering that all the plan lengths may be obtained by direct projection from the front elevation, and that all

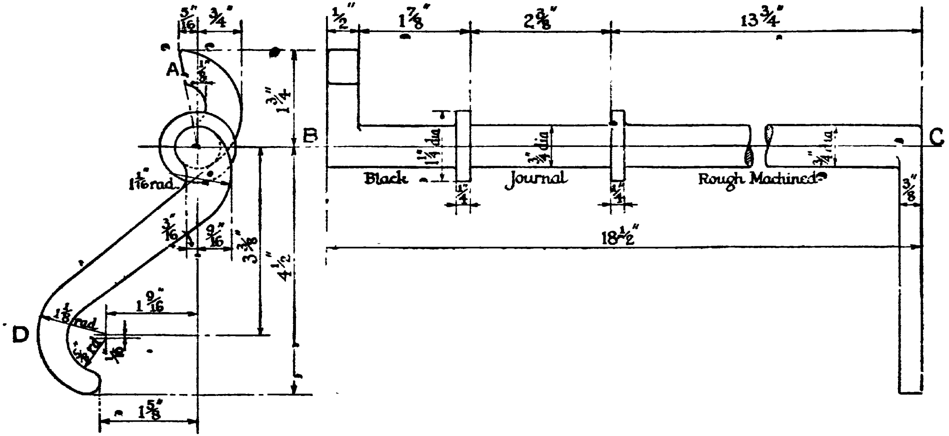
A
B
C
D
5/16"
3/4"
1 3/4"
1 1/16" rad.
3/16"
9/16"
3 3/8"
4 1/2"
1 9/16"
1 1/8 rad
1 5/8"
1/2"
1 7/8"
2 3/8"
13 3/4"
1 1/4" dia
3/4" dia
3/4" dia
Black
Journal
Rough Machined
1/4"
1/4"
3/8"
18 1/2"

Fig. 62

widths in the end elevation become depths or heights in the plan.

The last drawing, fig. 62, is a further example of parts being made right and left hand, or one hand and opposite hand. In each head or carriage of the machine a pair of such levers is required, one to act on each end of the faller, and made exactly as shown in the drawing, and the other its mirror image, or, as it is commonly stated, opposite hand.

Under modern methods of mass production in engineering workshops, a drawing should show what parts are to be machined in addition to showing the shape and dimensions. To attain this object comparatively elaborate systems have been introduced. Fig. 62 fulfils this requirement on a very elementary scale as indicated by the notes made under the circular parts of the front elevation, viz.: *Black*, *Journal*, and *Rough Machined*. That part marked "black" is to be left in the condition as received from the blacksmith; the part marked "journal" indicates it is to receive in the lathe the specially smooth finish required to reduce friction to a minimum; while the part marked "rough machined" is to be machined without any special considerations as to its exact size or finish.

The example in fig. 62 is worth careful study as regards the method of dimensioning. The shapes indicated in the end elevation lend themselves to many methods of dimensioning. That shown is good practice, as all dimensions, wherever possible, are referred to the vertical and horizontal centre lines as datum lines.

CHAPTER VIII

DRAWINGS TO SCALE

In making drawings of machine details it frequently occurs that the overall sizes are much greater than the length and breadth of the paper available. For instance, a spinning-frame gable may be about 6 ft. wide and about 5 ft. high; again, the drawing-roller of a roving frame may be, say, 2¼ in. diameter by 24 ft. long. To draw such details in their proper or full size would obviously lead to large unwieldy drawings, if, indeed, paper could be obtained to accommodate them. To obviate these difficulties, the device of drawing the part exactly in proportion, but on a smaller scale, is adopted. The basic idea is simple in the extreme—some fraction of an inch, such as ½ in., ¼ in., &c., is taken to represent 1 in., or, more correctly, some part of a foot, such as 6 in. or 3 in., &c., is taken to represent 1 ft. In the cases mentioned, the finished drawings would represent the part absolutely, except that they would be only one-half or one-quarter full size. This fact is no disadvantage, as the *proportions* or ratios of the parts remain constant. Drawings made in this way are said to be "drawn to scale". The illustrations in this work may be regarded as drawings to scale; in nearly every instance they have been drawn full size or half size, but all are shown on a much smaller scale, having been reduced for reproduction.

The scales most commonly used are those which form simple and definite fractions of 1 ft.; these are 6 in. to 1 ft., or ½ full size; 3 in. to 1 ft., or ¼ full size; 1½ in. to 1 ft., or ⅛ full size; ¾ in. to 1 ft., or $\frac{1}{16}$ full size; ⅜ in. to 1 ft., or $\frac{1}{32}$ full size; 1 in. to 1 ft., or $\frac{1}{12}$ full size; ½ in. to 1 ft., or $\frac{1}{24}$ full size; ¼ in. to 1 ft., or $\frac{1}{48}$ full size; and ⅛ in. to 1 ft., or $\frac{1}{96}$ full size. Occasionally, for special purposes, such scales as 9 in. to 1 ft., or ¾ full size, and $\frac{1}{16}$ in. to 1 ft., or $\frac{1}{192}$ full size are used. Again, in exceptional cases, special scales, such as 2½ in. to 1 ft., have to be used. The scale used should always be marked on the drawing, either in the form of, say, "6 in. to 1 ft.", or "½ full size"; in the latter case ½ is termed the scale fraction, or the representative fraction. In very important drawings it is a good practice to make a drawing of the scale upon the drawing itself, so that any measurements which are not marked on the drawing may be taken off on a pair of dividers and referred to the scale. The reason for this procedure is that paper is liable to shrink, and, should it do so, the scale, if made on the drawing, will shrink in like proportion. Even when the drawing is made the same size as the object, the scale should be noted, either by using the term "Full size", or in the form "12 in. to 1 ft." For very small details, such as may be found in sewing machinery, it is sometimes advantageous to draw the parts larger than their actual size; in this case the scale would be noted by a remark such as, for example, "Twice full size", or "24 in. to 1 ft."

EXERCISE 53.—To construct a scale of $\frac{1}{12}$ to read feet and inches, and to be long enough to measure 5 ft.

The representative, or scale fraction, is $\frac{1}{12}$, signifying that 12 ft. will be represented by 1 ft., or that 12 in. will be represented by 1 in. If 1 in. thus represents a foot, 5 in. will represent 5 ft., and the scale must be at least 5 in. long. It will be seen presently that it will be a distinct advantage to make it at least 6 in. long.

Draw a horizontal line AB, fig. 63, 5 in. long, from left to right, and extend it by 1 in. from A to C, right to left. The line AB must be divided carefully into five equal parts, each 1 in. long (it may be set out by the dividers by carefully setting the points 1 in. apart, and then measuring the overall distance as a check). At the points indicated, C, A, D, E, F, G, B, set up short vertical lines about $\frac{1}{4}$ in. high. Complete the rectangle CBHK. Divide AC first of all into halves, then divide each half into two, making four equal parts in all. Next divide each of these quarters in three equal parts, making $4 \times 3 = 12$ equal parts in all. Each of the divisions AD, DE . . . GB will represent 1 ft., and each of the twelve smaller divisions in CA will represent 1 in. The scale will be completed by distinguishing the inch marks as shown, and by adding the figure numbers, noting that the point A (0) is the starting-point, and that the numbers are marked to right and to left of it.

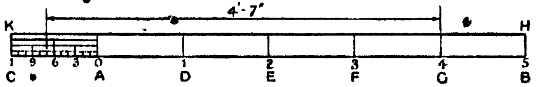

Fig. 63

Now to use the scale: Suppose that a distance of 4 ft. 7 in. is to be transferred from the scale to the drawing; set one point of the dividers to the mark indicated by 4 ft, and the other point to the mark indicated by 7 in. The distance between the two points will then be 4 ft. 7 in., as illustrated in the figure. In such a small scale fractions of an inch are obtained by estimation, but in larger scales the usual fractions of an inch may also be drawn in. To gain further experience the student should also work out the following two exercises.

Exercise 54.—Construct a scale of ¼, to read feet and inches, correct to ¼ in., and to be capable of measuring a maximum distance of 3 ft.

Exercise 55.—Construct a scale of 2¼ in. to 1 yd., the scale to show feet, and to embrace a maximum dimension of 4 yd.

When the divisions on the scale or rule become very small, correct reading becomes difficult, and it is much more convenient to use what is termed a diagonal scale. The principle of the diagonal scale depends on the properties of similar triangles, and may be demonstrated by the following simple example: Suppose it were desired to divide the distance AB, fig. 64, into three equal parts. On AB construct the rectangle ABCD, making the depth BC any size which can be conveniently divided up into three equal portions. Join the points AC by the diagonal line, and divide BC into three equal portions, BE, EF, and FC. Now draw EG and FH parallel to the given line AB, cutting the diagonal AC at K and L respectively.

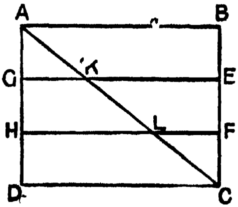

Fig. 64

The triangles ABC and LFC are similar, therefore, since FC is ⅓ of BC, LF is ⅓ of AB. Again, the triangles ABC and KEC are similar, so that since EC is ⅔ of BC, KE is ⅔ of AB. The three lines LF, KE, and AB are thus in the proportion of 1, 2, and 3. The principle may be further demonstrated by the following practical example:—

Exercise 56.—Construct a diagonal scale to measure a maximum length of 4 in., and to be correct to $\frac{1}{100}$ of an inch.

On the horizontal line AB, fig. 65, construct the rectangle

ABCD, 4 in. + 1 in. = 5 in. long, and 1 in. deep. Divide AD into ten equal parts, and through the various points draw parallels to AB as shown. Divide AE and DN into ten equal parts (10 × 10 = 100), and join up these points diagonally as shown. The scale is then completed by adding the desired figure numbers.

The scale may be used as follows: Suppose a dimension of 4·63 in. is required. Set one point of the dividers to the inch marked 4 on the base line CD, and the other on N; 4 in. will separate the points. Move the point on N to the mark 6 on ND; 4·6 in. now separates the points. Move the point on the mark 6 up the diagonal, starting from 6, until it meets the horizontal line which starts at 3 on the line DA; the distance between the divider points will now be that required, viz. 4·63 in., or $4\frac{63}{100}$ in.

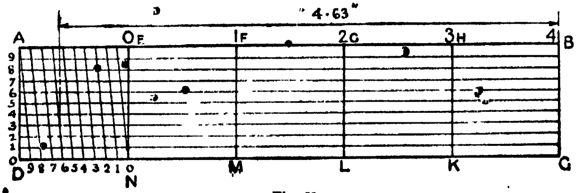

Fig. 65

N.B.—The divider points will, of course, be kept in a line parallel to the base line DC.

Exercise 57.—Construct a diagonal scale to measure a maximum of 3 in., and to read eighths and sixty-fourths of an inch.

Drawings of details should always be made to as large a scale as possible; small scales should only be used when circumstances compel. The ordinary rule should be used for such scales as full or half-size, the sizes in the latter case being halved mentally before they are transferred from the object to the drawing itself. When smaller scales, such as 3 in. to the foot, and less, have to be used, the student should provide himself with a proper drawing-scale, or set of scales. These scales are made in many materials, e.g. ivory, boxwood, cardboard, vulcanite, steel. The first is the best, but most expensive. Boxwood is most generally useful. Cardboard scales have the advantage of cheapness, but are easily damaged. Vulcanite scales are easily affected by changes of temperature, while steel scales are good, but expensive, and liable to rust.

Boxwood scales are made in various sections, four of which are illustrated in fig. 66. A is a good, though not commonly used, form; B shows the double-bevelled type, and C the so-called oval section, both of which are much used. All the above three have four marked edges, upon each one of which two different scales are marked, reading from opposite ends. Thus, each shows eight different scales, usually 3 in. and 1½ in.; ¾ in. and ⅜ in.; 1 in. and ½ in.; and ¼ in. and ⅛ in. The triangular form shown at D, while not much used, possesses the advantage of having six faces upon which twelve scales may be marked.

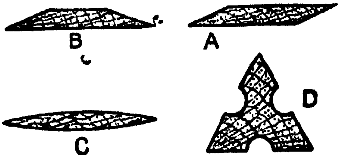

Fig. 66

Presuming that the student will now have added a suitable scale, or a set of scales, to his equipment, the following exercises may be worked out:—

Treadle-lever.—Fig. 67 gives a front elevation and plan of a treadle-lever, part of the shedding mechanism in a power-loom for weaving plain cloth. The treadle-lever is fulcrummed on a pin which passes through the hole A, the boss for which is provided with an oil-hole. The shedding wyper, which gives motion to the treadle, acts upon a small anti-friction roller or bowl which runs in the plain bearings indicated at B. The motion of the end of the treadle-lever is communicated to the leaf or lamb by pins screwed in at C and D, one pin only being used in each treadle of a pair.

Exercise 58.—Draw front elevation and plan of the treadle-lever shown in fig. 67, to a scale of 6 in. to 1 ft.

The front elevation should be drawn in first, using the horizontal centre line EF. and the vertical centre lines passing through A, B, C, and D, upon which to build up the view. It will be found possible to complete this view except for the ribs indicated at G. The plan should then be drawn, all lengths being obtained by projection, and the front elevation completed from the plan. As usual, care should be taken to see that each view corresponds exactly with the other. The long sloping lines may be drawn in either with the aid of the T-square, or with the long edge of the 60 set-square.

Exercise 59.—Draw a sectional view along the vertical centre line passing through B, fig. 67. (This view is not absolutely necessary, but it is instructive.)

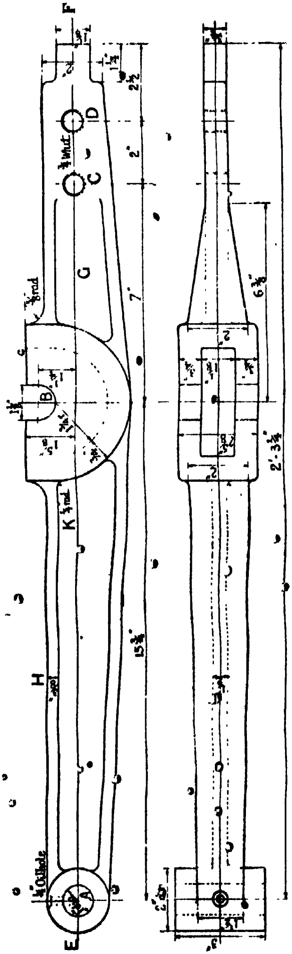

Fig. 67

It is important to provide oil-holes in such positions as that indicated in boss A, which is an important bearing surface, inasmuch as treadle-levers are practically in constant motion. A small hole, ¼ in. dia., is first drilled and then countersunk with the aid of a larger drill, in order to facilitate the insertion of the spout of the oil-can. In dimensioning tapped holes, such as are indicated at C and D, it is sufficient to mark the diameter and the kind of thread to be used. The word diameter need not be used here, since a tapped hole is obviously circular, but it is important to mention the kind of thread, as this may be Whitworth, gas, fine, or any of the numerous forms of thread in general use.

Students in drawing classes occasionally make working drawings from wooden models and patterns, as well as from the actual objects. In this connection the student should be careful to distinguish between actual wooden models and actual patterns as used by the moulder. In the former case the sizes taken from the model will be the correct sizes to appear on the drawing, but in the latter case all the sizes may have to be modified. The molten metal used in the casting process invariably contracts when cooling, and to allow for this contraction the wood pattern is made larger; the usual allowance for cast iron is $\frac{1}{8}$ in. per foot. To take the shrinkage into account, therefore, it is necessary either to reduce each size as it is measured by about $\frac{1}{8}$ in. per foot, or to use a pattern-maker's shrink rule, the dimensions on which are made slightly larger than the normal to allow for the shrinkage.

The length of the treadle-lever is great in comparison with its greatest breadth or depth, but the treadle is not a suitable object for being shown "broken", since its section varies at practically every point throughout its length. For this reason, it is imperative that all of it should be drawn, either full-size or to some scale such as is suggested in Exercise 58.

The dimension indicated at K, viz. $\frac{1}{4}$ in. rad., appears once only on the drawing, although there are at least six places where it might correctly appear. Where such a dimension only appears once, it is understood, of course, that all the radii in similar positions have similar dimensions. The same is true with regard to the dimension at H. It is important to avoid duplication of sizes wherever possible, in case these sizes may have to be altered at some future time.

Sliver-guide.—In finisher cards which are fed from cans, the slivers are usually led on to the feed-cloth through a set of sliver-guides, one kind of which is illustrated in fig. 68. The guides are mounted on a rod which passes through hole A, each guide being held in position on the rod by a ⅜-in. set-screw. The guides partially encircle the feed-cloth roller, located in the space B, and, by means of the thin broad-bladed parts C, keep the slivers in their required positions.

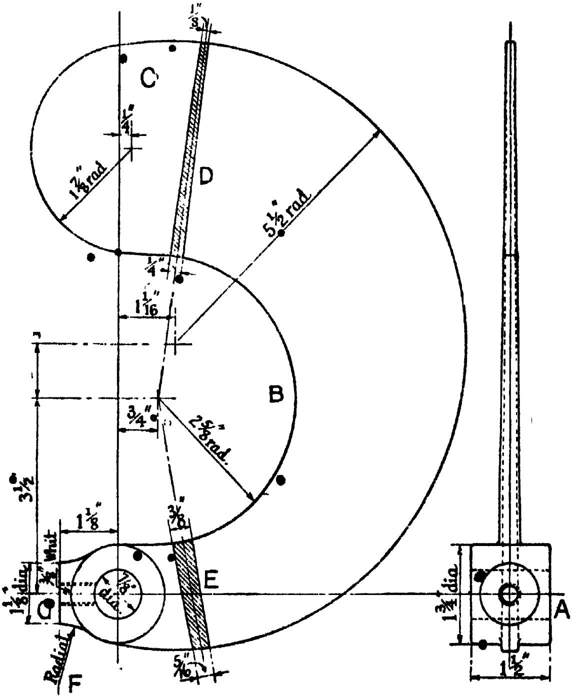

Fig 68

Exercise 60.—Draw the front and end elevations of the sliver-guide, illustrated in fig. 68, to a scale of half full size.

The front elevation is drawn first, and it should be noted that there is need for great accuracy in laying out the various centre lines in order to ensure that the various curves will join up correctly.

The example demonstrates a common and useful departure from ordinary methods. A glance at the end elevation shows that, partly due to the comparatively small scale, and partly to the small variation of the dimensions concerned, the view is somewhat confused. To prevent confusion, and to make the shape of the guide perfectly clear, two sections are shown at D and E. The departure from regular practice consists in showing the sections *in* the elevation, and on a line representing the centre line of the plane across which the section is taken. It will be seen that this method saves a lot of trouble, as otherwise the sections would have to be projected at somewhat awkward angles.

There are two points in the dimensioning that are worthy of notice. In sizing up the tapered sections, see that the locating lines are parallel to the centre line of the section, and that the dimension line is at right angles to the locating lines. These lines are readily drawn in with the aid of the set-squares, following the method outlined in Exercise 25. The second point concerns the dimension line shown at F; the type of dimension line shows it to be a radius, and the line of its centre is indicated. In such a case the dimension of the radius is not important, and its exact size is not easily found. It is sufficient, therefore, to write the word "radial" as shown.

The small boss or patch indicated at G is typical of the general method of strengthening a boss, such as A, which has been weakened by the removal of the metal necessary to obtain the $\frac{3}{8}$-in. tapped hole.

Belt-fork Stud Bracket.—Fig. 69 presents, in front elevation and plan, two views of a cast-iron bracket in which is bolted the stud upon which the belt-fork is fulcrummed, the method indicated being that adopted in many looms. The bracket is bolted to the loom gable by means of a $\frac{5}{8}$-in. bolt passing through the hole A. The bracket is prevented from swivelling on the single bolt by being checked into the rib of the gable; the small part cut away is indicated at the point B. The stud is bolted in an upright position through the slot C, a slot being used to permit of adjustment.

Exercise 61.—Draw front elevation and plan of the belt-ork stud bracket, illustrated in fig. 69, to a scale of ½.

In this case it will be most convenient to draw the plan irst, care being taken to leave sufficient space for the front levation to be projected above. The plan is symmetrical bout the horizontal centre line, and this should therefore be used both as a base upon which to build up the drawing, and as a datum line for dimensioning. There is no distinctive vertical centre, but that shown passing through the slot C should be used in the same manner, as it really represents the centre line of the stud, the holding of which is the function of the bracket.

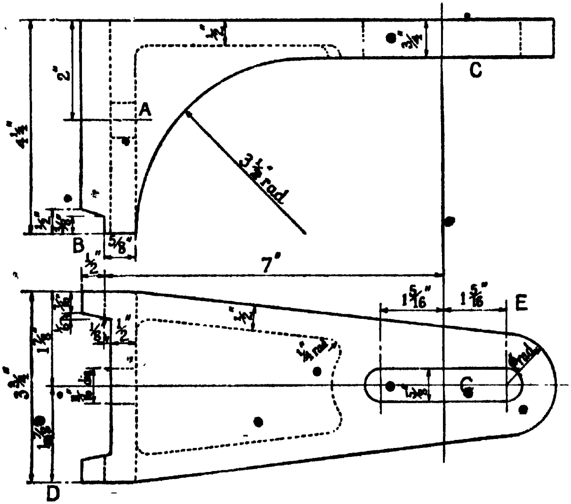

Fig. 69

As an additional exercise, it would be useful to take the following:—

Exercise 62.—Project an end elevation from the fron elevation shown in fig. 69. Such a view is not an essentia one, but it will serve the useful purpose of exhibiting the characteristic shape of the bolt-hole A.

In drawing circles, or radii, such as are used in the plan, where accuracy is desired, the student will find it a wise plan to check the radius or diameter after it has been lightly drawn in, with his rule. This is necessary because of the variation in the tightness of the compass joints, because of the variation in the pressure to obtain the requisite type of line, and because the thickness of the compass pencil tends to prevent the proper size from being picked off the rule or scale. As a check on accuracy, teachers should provide students with accurately made tracings of the details being drawn. Such tracings should, of course, be on transparent paper, such as that known as "detail tracing paper", and may quite well be in pencil. If the student applies such an accurate tracing to his own drawing, a glance is sufficient to reveal any inaccuracies.

The dimensions indicated at D and E, fig. 69, call for some slight notice. Those at D might be regarded as of little use, as the overall size, 3¾ in., may be looked on as covering or including both. The purpose of introducing the two similar dimensions is to show beyond any possible doubt that the horizontal centre line divides the object into two similar parts, i.e. that the plan is symmetrical about the horizontal centre line. In a somewhat similar manner the dimensions at E indicate that the slot is symmetrical about the vertical centre line.

As a small point in design the student should note that while the average thickness of the metal is generally ½ in., it is increased to ¾ in. round the slot C. This is done to compensate for the removal of the metal to form the slot, and to enable the slotted part to sustain the crushing action which takes place when the stud is bolted in position. Such a thickening of the section is not so necessary on the base or sole of the bracket, since this part is strengthened by the two ribs, one on each side of it.

This example, like the two previous ones, is intended to be drawn half size, and as such a scale is likely to be taken directly from an ordinary rule, it may not be out of place to suggest an easy method of halving sizes on a rule. Sizes such as $3\frac{3}{8}$ in. may be halved by first of all halving the 3 in. ($1\frac{1}{2}$ in.), then halving the $\frac{3}{8}$ in. ($\frac{3}{16}$ in.), and finally adding the two results ($1\frac{1}{2}$ in. + $\frac{3}{16}$ in. = $1\frac{8}{16}$ in. + $\frac{3}{16}$ in. = $1\frac{11}{16}$ in.) Such a process seems involved, but it is not really so. Sizes such as $4\frac{3}{8}$ in. are easily halved, because the whole number is an even number, the value being $2\frac{3}{16}$ in. But, where the whole number is odd, the half may be obtained readily by a somewhat mechanical process as follows: Take, for example, $5\frac{3}{8}$ in., say the half of 5 is $2\frac{8}{16}$, not $2\frac{1}{2}$, then $2\frac{8}{16} + \frac{3}{16} = 2\frac{11}{16}$.

Card-roller End Ring.—In certain cards the rollers (feeders, workers, strippers, and doffers) have the wooden staves, or leather filleting which carry the pins, screwed to wood lagging which forms the body of the roller. This wood lagging is in turn secured to cast-iron bosses or rings, one of which (an end ring) is illustrated in fig. 70. The roller arbor passes through the hole A, the ring is shrunk on the arbor, and the lags are held by set-screws which fit into the holes B. The end rings have a flange as indicated at C, while the middle rings are somewhat similar, but have no flange.

EXERCISE 63.—Draw a half front elevation and an end elevation—half outside view and half sectional view—of the card-roller end ring illustrated in fig. 70 to a scale of 6 in. to 1 ft.

The front elevation is obviously the first view to draw in this example, since it consists mainly of circles, or rather semicircles, because only one-half is required. The same sizes as are needed to draw the front elevation are then projected across to the end elevation; duplication of measurement is thus avoided.

The whole figure is a good example of what might be termed a "shorthand" method of producing mechanical drawings. Parts of three views are shown, none of the views being complete in itself, but at the same time all the necessary information is given. This method is often adopted when the object under consideration is circular and perfectly symmetrical about one or both of its centre lines.

It will be noticed that only one of the tapped holes B is shown in the end elevation. The reason for this is that cerrect projection of the holes would be almost impossible because of their small size and peculiar shape. The projection of that hole on the horizontal centre line would, of course, be a circle, but the others would be of varying elliptical shapes. All the necessary information, however, concerning the number, kind,

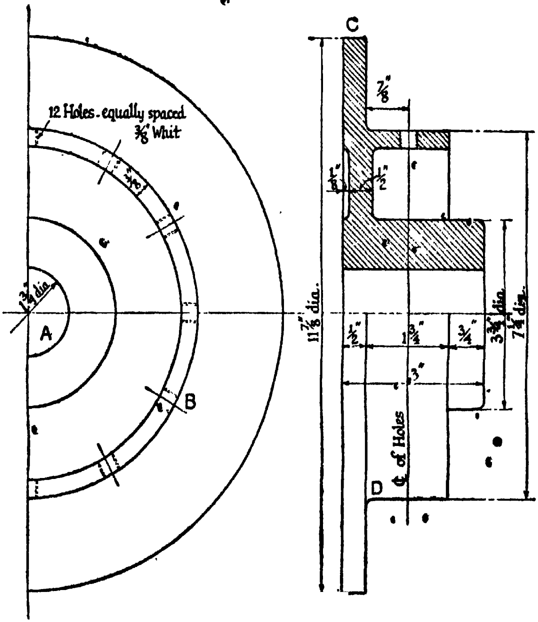

Fig. 70

size, and location of the holes is given, and any further work expended on this part of the drawing might be regarded as useless elaboration.

One good feature of drawing the end elevation as shown is that it obviates the use of dotted lines, an advantage which becomes more obvious as the section becomes more complicated.

The rounding out or fillet at D is required in order to strengthen the junction of the metal composing the thin flange with the metal forming the body of the ring. Such fillets are all-important in castings, as it happens that the minute crystals forming the cast iron always arrange themselves when cooling with their cleavage planes at right angles to the surface. Hence, when two surfaces meet at right angles, the disposition of the crystals forms a possible source of weakness. This defect is obviated, wherever possible, by the introduction of a suitable fillet, so that there is no sharp angle resulting from the juxtaposition of the two surfaces concerned.

In drawing the end elevation, which consists of five concentric semicircles, the student should be careful to keep the compass needle as nearly vertical to the surface of the paper as possible; otherwise, he may make a large hole and spoil the accuracy of the drawing. When a finely finished drawing is required, use may be made of one of the many forms of horn or metal centres, the former being preferable, since it is transparent and cannot readily injure the compass point. A horn centre consists of a thin disc of horn, $\frac{1}{2}$ in. to $\frac{5}{8}$ in. diameter, and about $\frac{1}{32}$ in. thick. On its under-side are three fine projecting needle points, while on its upper surface are two fine lines intersecting at right angles. The centre is placed where required on the drawing, the intersecting lines made to coincide with the drawing centre lines, and the point placed on the horn itself; all injury to the paper is therefore prevented. A cheap substitute consists of stiff adhesive linenized paper, but this type has the disadvantage of being adhesive, and of having to be frequently renewed. The use of all such centres may, to a great extent, be avoided by taking care to provide oneself with double-jointed compasses, and by using "trammels" (beam compasses) for all circles of large diameters.

Delivery-roller Swing Lever.—In certain drawing-frames provision has to be made for the delivery pressing-roller or roll being allowed to rise and fall in accordance with the thickness of the sliver. The roller is then carried in a pair of swing levers, one hand of which is illustrated in front elevation and sectional plan in fig. 71. The lever swings on a stud passing through the hole A, and carries the roller arbor in hole B, which is generally bushed with brass or gun-metal. A wheel guard is carried on a small stud bolted into the hole C, and provision is made at D to enable spring pressure to be maintained when required by means of a hooked rod fitting into the semicircular recess shown.

EXERCISE 64.—Draw front elevation and sectional plan of the delivery-roller swing lever shown in fig. 71 to a scale of 6 in. to 1 ft.

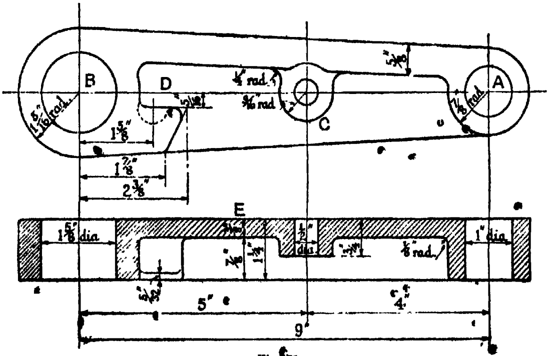

Fig. 71

The horizontal and vertical centre lines will naturally be drawn first, after which the front elevation may be practically completed. The plan is then projected from the *centre line* of the front elevation, so as to obtain the required section.

The main reason for introducing this example is to provide another case where a section is more useful than the ordinary outside view. A little consideration will show that, if the plan were projected in the usual way, the only full lines to appear would be the four bounding lines, while the remainder, the comparatively complex detail, would be shown dotted. The drawing of the section obviates the use of dotted lines, and renders the complete shape more easily understood.

Where one view of a drawing has only one horizontal and one vertical centre line, and another view is a section, it is generally understood that the section is taken on one or other of the centre lines. Where there is more than one centre line, or where the section is taken across some plane which does not contain a centre line, the exact line should be indicated definitely, as is done in fig. 58.

EXERCISE 65.—Draw a section on the vertical centre line passing through the hole C, fig. 71; this section will, of course, be projected from the front elevation.

In dimensioning sections, sizes should, where possible, be kept away from the section lines, to prevent possible confusion; this is done in fig. 70. Where the dimensions are put on the section, the section lines around them should be omitted, as is done at E, fig. 71. Another small point worth some attention has regard to dimensions such as the $1\frac{5}{16}$-in. radius indicated at B. To prevent the dimension from being read $\frac{15}{16}$ in., the whole number 1 should be as high as the $\frac{5}{16}$. The dimension $1\frac{5}{16}$, as well as the radii of the bosses A and C, might have been marked as diameters, but they have been stated as radii, because all three are pattern-maker's sizes only, and the pattern-maker requires the radius rather than the diameter in order to set his dividers when marking off.

Doffer Bearing-bracket.—In certain cards the doffer—the roller which strips the carded material from the cylinder—is carried in bearing-brackets bolted to the machine gable. An example of one hand of such a bracket is given in front and end elevations in figs. 72 and 72 *a*. The hole A, which is suitably bushed with brass or gun-metal, carries the doffer arbor and forms the bearing in which it rotates. The bracket fits over the top of the gable at the check B, and is fixed to it by bolts which pass through the holes C; corresponding slots are formed in the gable. To secure easy and accurate adjustment of the doffer to the cylinder, a collared screw, fitted into a fixed adjusting bracket, is passed through the tapped hole D, and any rotation of this screw moves the bracket, and consequently the doffer, a corresponding distance. The holes at E and F are used to carry an adjustable bearing for a cleaning-brush, the bracket being fulcrummed on a stud fitted into the hole F, and locked in the required position by a bolt through the hole E.

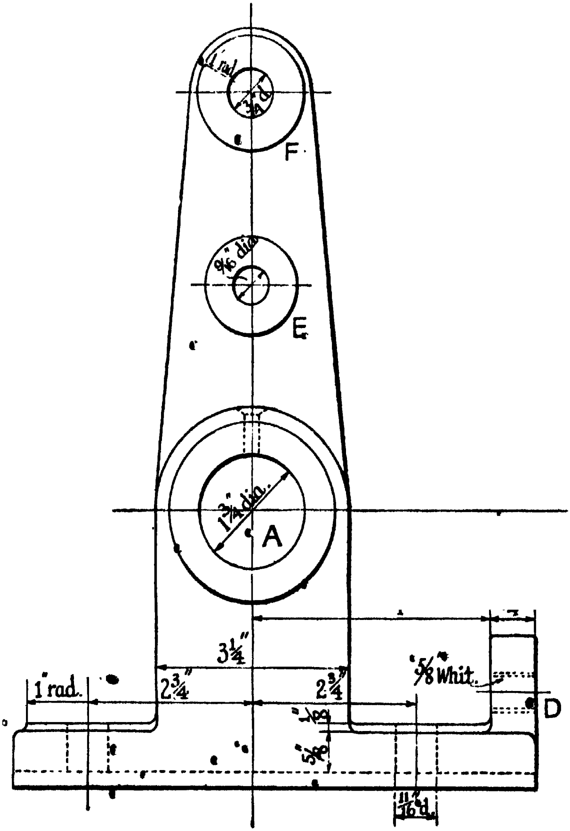

Fig. 72

EXERCISE 66.—Draw front and end elevations of the doffer bearing-bracket illustrated in figs. 72 and 72*a* to a scale of 6 in. to 1 ft.

Little difficulty should be experienced with this example, as a

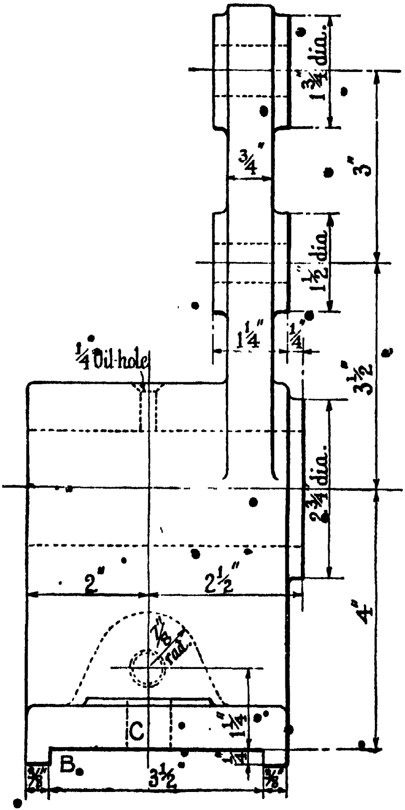

Fig. 72a

comparatively simple machine part has been chosen in order to give the beginner some practice in what is known as shade-lining.

The drawing should be completed with the ordinary thickness of lines, then the dimensions added, and, lastly, the shade-lining is performed. The purpose of the shade-lines is to give relief to the otherwise flat appearance of the object as ordinarily drawn, by the introduction in appropriate places of heavy lines representing these parts in shade or shadow. The student should imagine that a lamp or other source of light is placed somewhat above, a little to the left, and slightly in front of the object, so that the rays of light fall on the object at an approximate angle of 45°. The direction of the rays of light will thus cause the right-hand side and the bottom of each view to be in shadow, this effect being represented by thickening up the lines concerned to about twice the normal thickness. Holes are shade-lined oppositely, i.e. on the top and left hand, since the rays of light would penetrate the hole, illuminate the bottom and right-hand parts, and leave the top and left-hand parts in shadow.

It is not difficult to shade the straight lines, but it must be remembered to add the thickness outside the proper line. The following hint will be useful in regard to the more difficult treatment required by circles and curves generally. In shade-lining any circle, first take the actual radius of the circle on the compasses, and then move the needle point downwards and to the right to a point very close to the real centre, but lying as indicated at an angle of 45° to it with regard to the horizontal or vertical. Now draw in the part of the shade circle desired, according to whether the original circle represents a hole or a circular boss. If the former, the shade-line will be added inside the hole; if the latter, the shade-line will be outside the boss.

Exercise 67.—Make a plan projected from the front elevation and shade-line it according to the above instructions.

It is important that the shade-lining should be done last of all, so that the dimension and locating lines may be true, and not distorted or out of their proper position by the thickening of the various lines. Full lines only should be thus thickened, no further attention being paid, unless in exceptional instances, to any dotted detail. Similar treatment to above is followed for curved parts other than circles.

CHAPTER IX

SMALL ASSEMBLIES

After the student has conscientiously worked out the foregoing exercises, he should be able to produce, in pencil, workmanlike sketches and drawings of any simple single machine part. This chapter is devoted to a consideration of the next step in progression, namely, the drawing of small assemblies. From the drawing point of view, an assembly may be regarded as a group of parts drawn together in the same relative positions as they ultimately occupy in the finished machine; the relative position of each part in the group or assembly is clearly shown, but the position of the group with relation to the remainder of the machine is not shown. When the position of the group or assembly in the finished machine is indicated, the drawing may be regarded more properly as an arrangement drawing.

Assembly drawings may be drawn for various reasons. First of all, when parts of machines are being designed, it is usual to draw out the group of parts to see how each is to fit into its neighbouring parts, and to ensure that there is space left for all necessary motion, adjustment, &c. Such a drawing is preliminary only; it gives a more or less approximate idea of the feasibility of the design, and enables the leading dimensions to be fixed. Afterwards, each detail of the assembly is drawn out separately, and all necessary dimensions fixed; in addition, all parts are named, and usually numbered. The name of the part is given (1) according to its function in the machine, and (2) according to its position in the machine. In certain cases, however, old and commonly used names have to be used, simply because they are well-established, and change might lead to doubt and confusion. The numbering is important; a name may be easily changed, but a number is an unchanging reference. When the details are thus drawn out, the assembly is again drawn, all sizes, &c., being obtained from the finished details. The preliminary assembly drawing is now of little or no use, and may usually be discarded.

Secondly, an assembly may be drawn to take the place of detail drawings of its several parts. It thus serves a double purpose, showing all the necessary sizes to enable each detail to be made, and showing how to fit all these details together. Although this is usually an economy of time and labour in drawing, it is not always an advantage. It becomes less and less an advantage as the assembly becomes more and more complex. In modern "mass production" each separate part may be made by a different workman, and there will be less chance of error if each workman gets a drawing showing only the particular part with which he is concerned. Again, all designs are liable to be changed somewhat, and it is far easier to change or replace a small and comparatively simple detail drawing than to change a more or less complicated assembly. One small advantage of such an assembly drawing is that, since it shows how the various parts fit together, it is not so essential to develop a system of machining marks, reference to which has already been made.

Lastly, an assembly drawing may be made merely to show the relative positions of its component parts. In this case, the drawing should be developed on pictorial lines, no dotted detail being shown unless for special reasons.

Assembly drawings should be dimensioned according to the use to which they are to be put. If the various details are to be made from such a drawing, it must be fully drawn and completely dimensioned, although for the sake of clearness, it is unnecessary that all views be complete. If the drawing is merely to show how certain details are to be fitted together, only leading or design dimensions are essential. Again, it is sometimes necessary to perform certain of the machining processes after the various details have been fitted together; in such a case, these machining dimensions, as well as the leading or design dimensions, should be shown.

The student should make a practice of checking all finished drawings with the original sketches or other source of information, and, when doubt arises, refer, if possible, to the original part, model, &c., or wherever the information was obtained. In modern mass production, one small error on a drawing may lead to the scrapping of many parts.

In the drawing of assemblies there are two kinds of work in which the student should have practice: (1) the building up of assembly drawings from their component details, and (2) the drawing of details from the preliminary or finished assembly drawing. In the former case it is important that no dimension be taken for granted; all should be carefully measured, the assembly drawing thus forming an efficient check on the correctness of the details.

The remainder of this chapter is devoted to progressive examples and exercises in the drawing of the more simple forms of assembly.

Spindle Shaft Thrust-bracket.—In certain types of roving frames, cop-winding machines, &c., the spindles are driven by means of bevel pinions set-screwed to a long shaft, and gearing with corresponding bevel wheels. Wherever such bevel gears are employed, some means must be provided to counteract the thrust of the bevel; the word "thrust" refers to the force acting at the teeth of the gears and tending to separate or drive them apart. Ball-bearing thrust washers are often employed for this purpose, but less complicated methods are also still in use.

Fig. 73 shows the component parts of a thrust bracket used on the spindle-shaft of a certain type of roving frame: A is the thrust-bracket fixed to a rail of the machine by set-screws passing through the four holes in its base. The cylindrical boss at the top is tapped to receive the thrust-screw B; this screw terminating at one end in a hardened thrust-pad which bears against the end of the shaft, and has a squar filed or milled at the opposite end, so that it may be readil adjusted to compensate for wear. A standard lock-nut C i used to lock the thrust-screw B in its required position.

Fig. 74 shows these three component parts assembled i their correct relative positions.

Exercise 68.—Using the information given in figs. 73 an 74, draw front and end elevations of the thrust-brack assembly to a scale of half full size. Assume that no separat details are to be drawn, and dimension the views accordingly

The end elevation is conveniently drawn first, then, th front elevation, and all heights obtained by projection as i fig. 74. A plan is not absolutely necessary; it would serve t

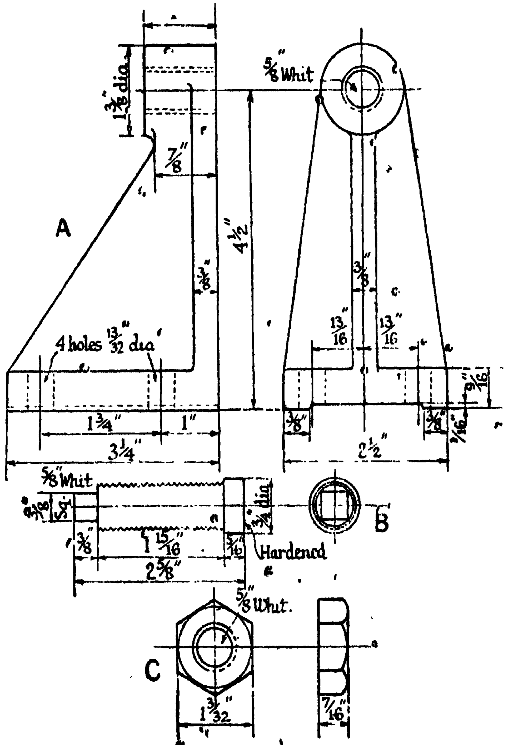

Fig 73

clear up any doubt as to the shape and position of the screw-holes in the base, but this same purpose is amply fulfilled by the note—"4 holes $\frac{13}{32}$ in. dia."—and the location of the dotted lines in the two elevations. At the same time a projected plan would form good practice.

Exercise 69.—Draw to a scale of half full size a plan of the parts in figs. 73 and 74 projected from the front elevation.

For the sake of clearness, the thrust-screw and lock-nut are not shown in the end elevation; the form of these two parts renders this unnecessary, as all the dimensions can be exhibited in the one view shown. The chain-dotted lines drawn diagonally across the square head of the screw in fig. 74 show the conventional method of indicating the elevation of a rectangular part, when the rectangular form is not more precisely indicated in any other view. The same kind of lines are often found marking a journal on a shaft, &c., but this usage is not warranted (except by long-standing custom), as it is undoubtedly best when one particular conventional sign represents one particular form only. To ensure that the thrust-screw will wear very slowly, the ¾-in.-diameter pad at the end should be subjected to a hardening process, and, to

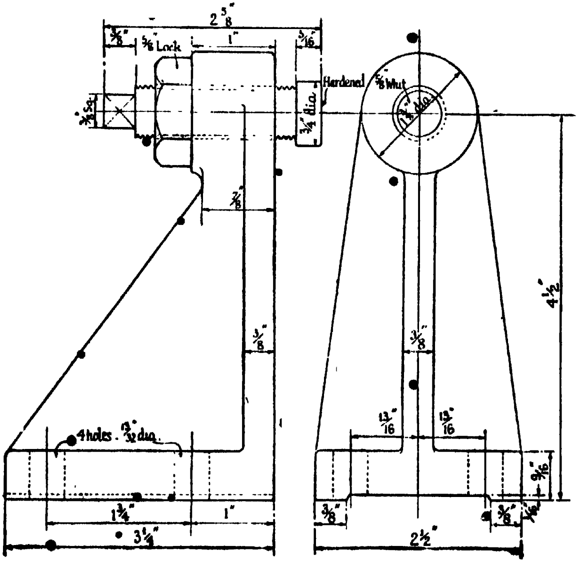

Fig. 74

indicate that this is required, a note to that effect, summed up concisely into one word, is put on the drawing.

Drawing-roll Cleaner Holder.—In practically all textile machinery where revolving rolls or rollers are made to act on the fibrous material, there is a tendency for stray fibres to be coiled on the roller, these in turn pulling round others, until the whole of the sliver laps round and is coiled on the roller. To prevent the consequent stoppage of the machinery, all such rollers are provided with some form of rubber or cleaner of the "dead" or of the "live" type. The former is fixed and merely rubs against the roller; the live type revolves either with or against the roller, but always at a different speed.

Fig. 75 illustrates one form of a "dead" rubber, such as is used on the drawing or front roller of certain types of card. The cleaner A has its concave surface covered with felt; this felt is in contact with the roller B, and is pressed firmly against the latter by means of the holder C, fulcrummed on a stud located in the open slot D. It is evident that the major portion of the holder is on the opposite side of the slot D to the cleaner A, and consequently the holder serves as a weighted lever to press the cleaner A upwards and firmly against the roller B. Stray fibres cannot then readily get round the roller, and so-called laps are, to a great extent, obviated.

Exercise 70.—Draw front elevation and plan of the drawing-roll cleaner and holder as shown in fig. 75, to a scale of half full size, and add a plan.

The front elevation should be drawn first, care being taken to work rigidly to the various centre lines, all of which must be drawn in at an early stage. The centre lines, both horizontal and vertical, which pass through the slot D, should be used as datum lines in dimensioning.

The cleaner is 6 ft. 3 in. long, and cannot, therefore, be readily shown to scale; it is sufficient, however, to show it broken off as in the lower figure; the break shown is that conventionally used for wood. The real length is indicated on the "unfinished" dimension line, i.e. a dimension line with an arrow-head and locating line at one end only. The diameter of the roller is indicated in a similar manner. Obviously,

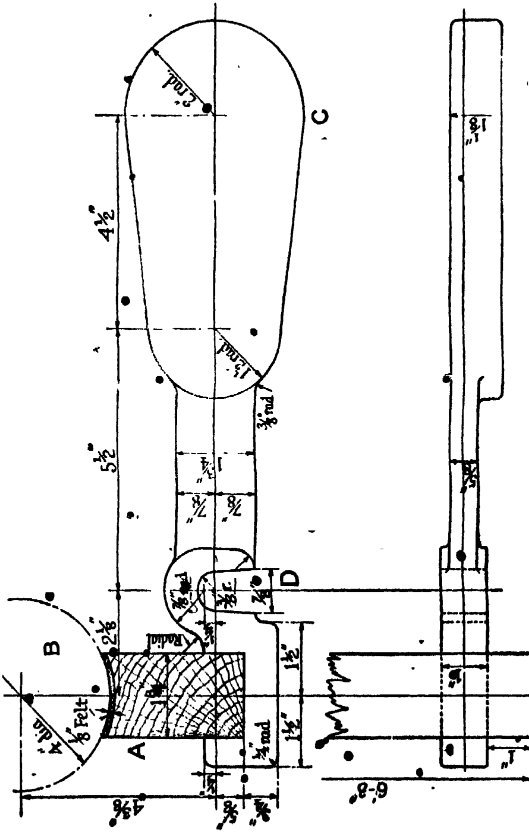

Fig. 75

this method of dimensioning should be applied only to parts of regular section.

The thickness of the metal above the open slot D is obtained by using a centre ¼ in. above the stud centre, as shown. This is done partly in order to ensure sufficient metal above the stud, because this is the part where fracture is most likely to occur, and partly to ensure that a reasonable amount of wear and tear may take place before the thinning of the section reaches the danger-point.

Retaining-roller Weight Lever.—In certain types of dry spinning-frames, e.g. those used for flax, hemp, and jute, the front feed- or retaining-roller is in one continuous length, and runs in brass or white-metal bearings fitted into the stands or bends of the machine. The pressing-rollers, which work in conjunction with the retaining-roller, are made in pairs, i.e. two cast-iron bosses are mounted on a steel arbor, and are pressed firmly against the front roller. Fig. 76 illustrates one method of applying the necessary pressure. A cast-iron lever A is fulcrummed on a pin passing through the hole B, and carries a weight at the hooked end C. A brass screw, having a square head D, is screwed into the half-round boss E, the outer face of the square head D being rounded out or grooved to fit the arbor F of the retaining-roller; the brass screw is made long to permit of adjustment to compensate for wear.

EXERCISE 71.—With the information supplied in fig. 76, draw front elevation and plan of the retaining-roller weight shown, using a scale of 12 in. to 1 ft., i.e. full size.

The front elevation should be drawn first, a commencement being made by drawing the main horizontal centre line. Next draw in the vertical datum line shown at the extreme left of the figure; a horizontal measurement of 4 in., and a vertical measurement of $1\frac{7}{16}$ in. will enable the sloping centre line of the brass screw to be drawn in. Similar horizontal and vertical measurements enable the centre lines of the hole B and its lug to be obtained; when these various lines are drawn, the student should work round each as much as possible, until the front elevation is complete. Afterwards, the horizontal centre line of the plan is inserted, and the plan drawn, all lengths being obtained by projection.

In drawing the screw and other sloping parts parallel to and at right angles to the screw centre line, use must be made of the set-squares as illustrated and described in Exercise 25, p. 35.

This example may be regarded as typical of drawings where

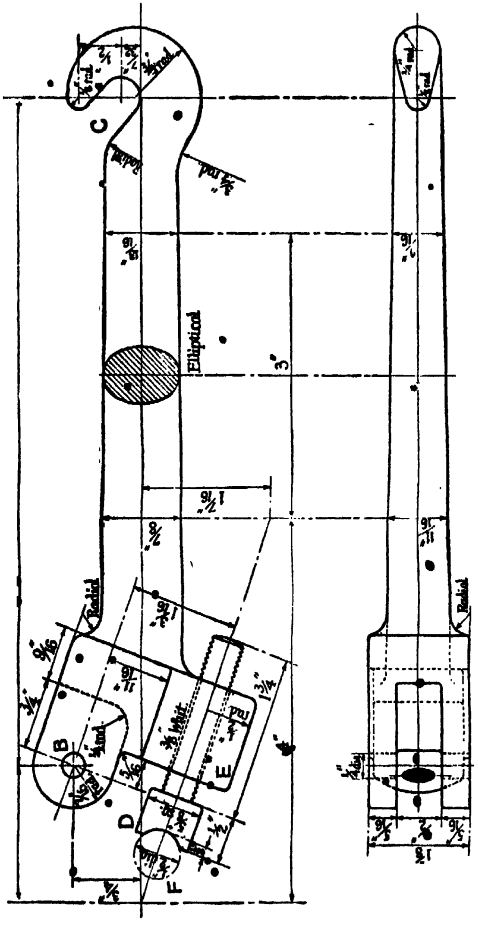

Fig. 76

a datum line lying outside the object is necessary. Its necessity and its usefulness will only be fully appreciated if the student should attempt to dimension the drawing without its aid, that is to say, if he manages to produce the drawing at all without its aid.

Attention should be paid to the method given of dimensioning the angle between the horizontal centre line of the lever proper and the centre line of the screw. At first sight it might seem reasonable to lay off this angle with the aid of the instrument known as a protractor, and to give the dimensions as so many degrees. A protractor is simply a segment of a circle, containing a diameter of the circle; the diameter is bisected at right angles by a radius, forming two right angles, and marking the centre of the circle. The curved side (semicircle) is divided into 180 equal parts or degrees, and numbered 0 to 180. One form of protractor is illustrated in fig. 77; it is made of celluloid, has a bevelled edge, and is about $\frac{1}{16}$ in. thick and 6 in. in diameter. It will be obvious that such an instrument can be used to record degrees only on a plane surface, so that, while it is easy to make measurements on paper, it is difficult in most cases to apply it directly to an object. Hence, the triangulation method shown is more generally useful. Nevertheless the protractor has its uses, and students of drawing would do well to acquire one, being

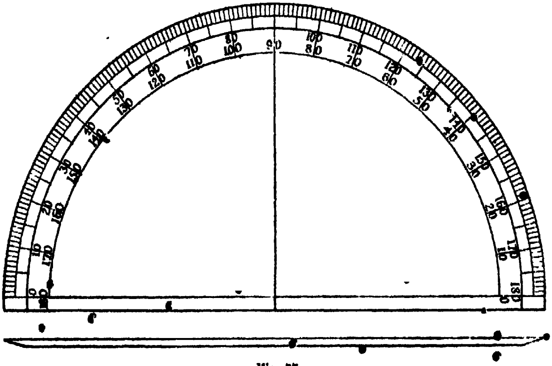

Fig. 77

careful that it is not too small; the size given above is regarded as a minimum from the point of view of general utility. The larger the protractor, the less becomes the possible percentage error, either in measuring or in marking off.

Wherever possible, angles of known size should be constructed by geometrical methods; when this is impracticable, the protractor may be employed, or use may be made of the scale of chords which is often found on the back of rules, &c. Such a scale is illustrated in fig. 78, and it is used as follows:

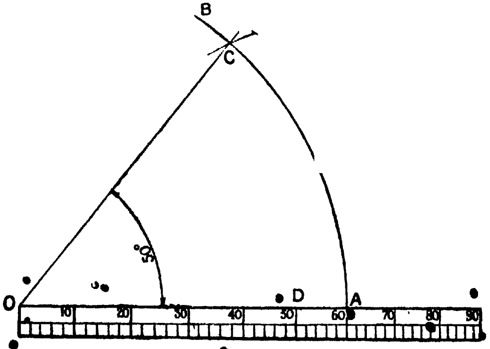

Fig. 78

Suppose it is desired to lay off an angle of 50°. Set the needle point of the compasses at O, and move the pencil to 60; with OA as radius describe an arc of a circle AB. Next, set the pencil to 50°, the required angle, and cut off a distance equal to OD on the arc AB, cutting the latter at C. Join CO, then COA is the required angle and is 50°.

Returning again to fig. 76, some difficulty may be experienced, in the plan view, in representing correctly the tapped hole and the half-round boss E. Both of these are virtually circles, but since neither of them is at right angles to the horizontal plane, i.e. both are inclined to it, they appear in the plan as ellipses. In each case the major axis is obtained by measurement, and the minor axis by projection from the corresponding points in the elevation. Except when the ellipses are large, the geometrical methods of drawing—one of which is given in Exercise 26—are not used, and one of the approximate methods often employed is as follows: Draw horizontal and vertical centre lines AB and CD, fig. 79, intersecting as shown, at E. Mark off EA and EB each equal to, say, 2 in., half the major axis, and EF and EG each equal to, say, 1 in., half the minor axis. On EA describe an equilateral triangle EAH. With E as centre, and EF as radius, describe the arc FLK, cutting EH in L. Join FL, and produce the line to M, cutting HA in N. With A as centre and AN as radius, describe the arc NP, cutting AB in P. Join NP and produce the line until it cuts the vertical centre line in D. With P as centre, and PN as radius, describe an arc of a circle;

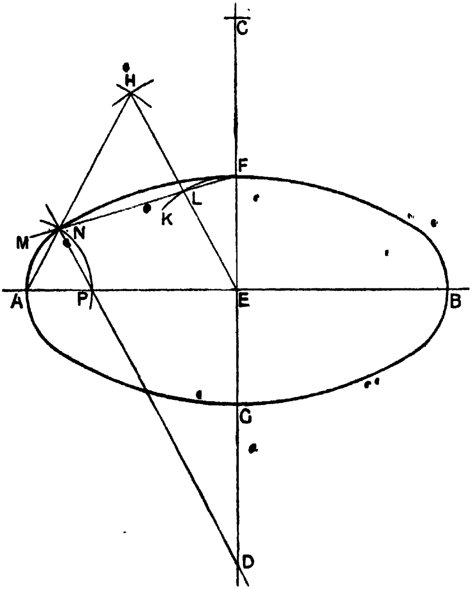

Fig. 79

with the same radius, describe a second corresponding arc passing through B. With D as centre, and DN as radius, describe an arc joining up the two small arcs and passing through F; with the same radius, and C as centre, describe a second corresponding arc joining up the first two small arcs and passing through G. The required approximate ellipse is then represented by the closed line AMFBG.

EXERCISE 72. -- Construct, by the above approximate method, an ellipse, the major and minor axes of which are 3 in. and 1½ in. respectively. Draw full size.

After the above exercise has been carried out little difficulty should be experienced in obtaining the ellipses required in the plan view of fig. 76, or in drawing the elliptical section shown in the elevation. In the case of very small ellipses, the geometrical construction to find the two radii may be dispensed with and the radii found simply by trials.

Top Roller Bearing-bracket.—In looms where the shedding or separation of the warp threads is performed by negative tappets or wypers, top roller mountings are often used to convert the negative shedding action of the tappet into a positive one. The top rollers consist of a steel arbor or arbors, to which are keyed or set-screwed cast-iron bosses. Leather straps, hooks, and twine connect the bosses to the upper staves of the leaves of the healds or cambs. Fig. 80 illustrates one form of bearing-bracket for a top roller such as is used in a certain type of loom for weaving plain cloth. The roller arbor fits into and oscillates in the bearing recess A; the bracket is supported in a hole in the upper rail (bow rail) of the loom, and has a comparatively long turned shank C to permit of adjustment backwards and forwards. To prevent any of the oil, used in the lubrication of the bearing, from dropping on to the warp yarn and thus adversely affecting the cloth, an oil-dish B is set-screwed to the bottom of the bearing as shown. It will be understood that at least two such brackets are necessary to carry the top roller; wide looms may have three, while in very wide looms there may be two or more separate arbors, each with a pair of bearing-brackets.

EXERCISE 73.—Draw a plan and elevation of the top roller

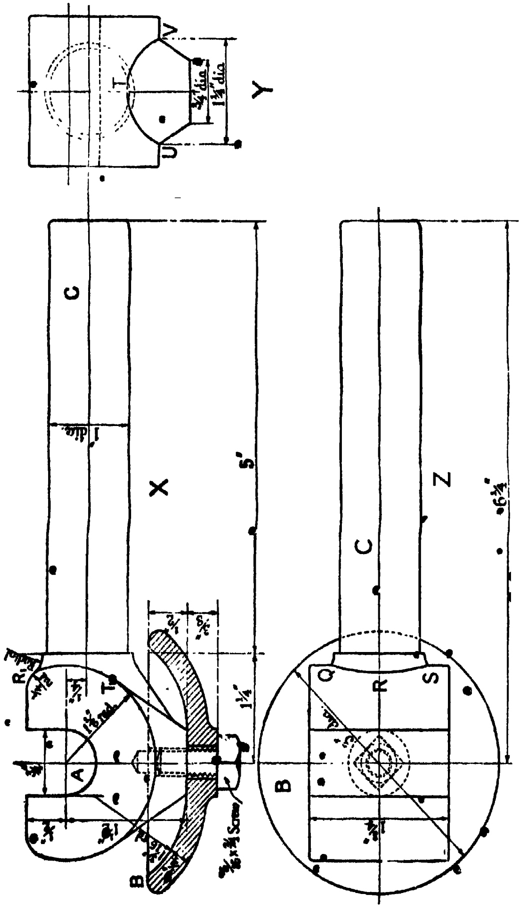

Fig. 80

bracket, illustrated in fig. 80, to a scale of full size, and add an end elevation.

This exercise will be found fairly easy to draw when the two horizontal centre lines and the vertical centre line have been correctly put in. It possesses, however, at least three points of interest to the student.

The three views in Fig. 80, marked X, Y, and Z, may be regarded respectively as front elevation (partly sectional), end elevation, and plan. The first point of interest is that the *end* elevation Y is the view seen from the *front* of the loom, while the front elevation X is that seen from the *end* or side of the loom. In cases of this kind it is important to remember that the names of the views refer more particularly to their positions in the drawing itself rather than to the relative positions occupied in the machine. For drawing purposes, as has already been pointed out, the front elevation is that which exhibits length and height; the plan, that which shows length and breadth; and the end elevation, that which shows height and breadth.

Again, the front elevation depicts the oil trough in section, this being done in order to exhibit its shape clearly without having recourse to dotted lines. The screw is not shown in section. It may be taken as a general rule in the drawing of sections that, if the central part is circular, as it very often is—a shaft, pin, stud, &c.—it is not included in the section, but is shown in its usual outside view. Any departure from this rule would only occur where it is desired or necessary to emphasize any special internal feature of the central circular part.

Lastly, the curves shown at R and T are approximations only. Each of them represents the intersection of two curved surfaces, and, as these intersections are not of special importance, and as the true intersections necessitate comparatively difficult geometrical constructions, the approximations shown would be considered sufficient for most practical purposes. In the plan Z, the points Q and S are obtained by using the radius marked "Radial" in the front elevation X, while R is obtained by projection from the corresponding point R_1; an arc is then drawn to pass through the three points. Similarly, in the end elevation Y, the points U and V are obtained by measurement, while T is obtained by projection from the

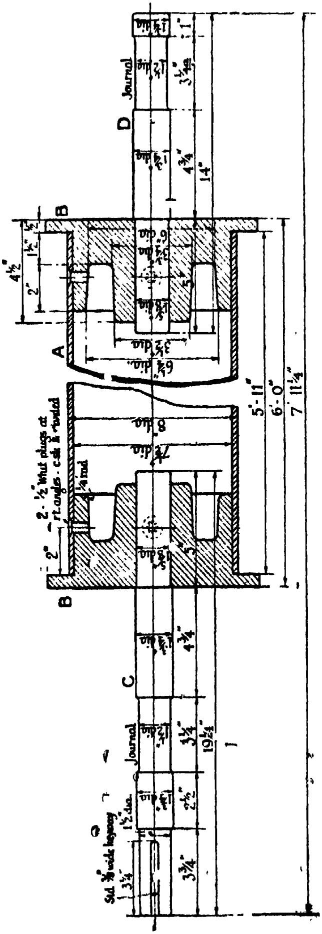

Fig. 81

corresponding point T_1 in the front elevation X. The projecting boss UTV in the end elevation is really part of a cone, and its sloping sides may be drawn, more properly, by making them parallel to the corresponding lines in the front elevation X.

Breaker Card Worker.—In waste breaker cards, such as are commonly used for dealing with fibres of flax, hemp, jute, &c., the worker rollers must be of strong and sturdy construction. Fig. 81 shows one form of such a roller. The body A is a steel tube 8 in. external diameter and ¼ in. thick; into its open ends cast-iron flanged bosses B are forced by hydraulic pressure, and additional security is obtained by fitting in screwed plugs as shown. The gudgeons or arbors are themselves shrunk into the cast-iron ends, i.e. the ends are heated, causing them to expand. While hot, and the hole thus larger than its normal size, the arbors are put in. As the ends cool they contract, the hole returns to its normal size, and in so doing, seizes on and firmly holds the steel arbors C and D.

EXERCISE 74. — Using the information given in fig. 81, make detail drawings of the four different parts, viz. tube, ends, and arbors, required for one complete worker. Scale 6 in. to 1 ft.

EXERCISE 75.—Use the details drawn in Exercise 74 in order to make an assembly drawing of the finished roller to a scale of ¼ full size.

The staves or lags, which carry the worker-pins, are held on to the body of the roller by countersunk screws. The tapped holes for receiving these screws are not shown. In practice, templates are made from the actual staves, and the holes drilled to correspond.

It will be noticed that the inside of the cast-iron bosses B are tapered, the actual amount of taper being ⅛ in. on each side. In practice, all cast parts are thus made, the taper being necessary in order to allow the wood or metal pattern to be easily drawn from the sand in the moulding process. The taper is technically known as "draw", and is provided on all surfaces which are in a vertical position in the mould. It will be understood that the tapered parts are naturally removed during any machining process on a particular surface. The short edges of the flanges B, and the longer surfaces in contact with the tube, would thus appear tapered in the rough casting, but in machining these surfaces the tapered part is removed. It is not, however, an invariable practice to show this taper on a drawing, although in many cases it is an advantage; and in several cases where the draw is certain to affect the design of adjacent parts it is an essential feature in the drawing.

There are two kinds of section lines used: (1) to indicate the cast iron of the bosses B, and (2) to indicate the mild steel of the tube A. Where two sectioned parts are in contact, the 45° section lines should be drawn in opposite directions in order to render the various parts more easily distinguishable. In a pencil drawing these sections may, after a little practice, be sufficiently accurately drawn in freehand, and as the drawing of these lines takes up a considerable amount of time, facility in drawing them freehand is worth striving after. It may prove a help to the beginner if the first few lines are ruled in with the aid of the 45° set-square and the remainder introduced freehand.

The keyway in the gear-side arbor is not fully dimensioned, only length and width being given. It is understood that all remaining dimensions would be obtained from a table of standard keys and keyways, such as is given on p. 66. The directional line between the note "std. ⅜-in.-wide keyway" and the elevation of the keyway itself is purposely irregular, so that there may be no chance of its being confused with the regular lines of the drawing proper.

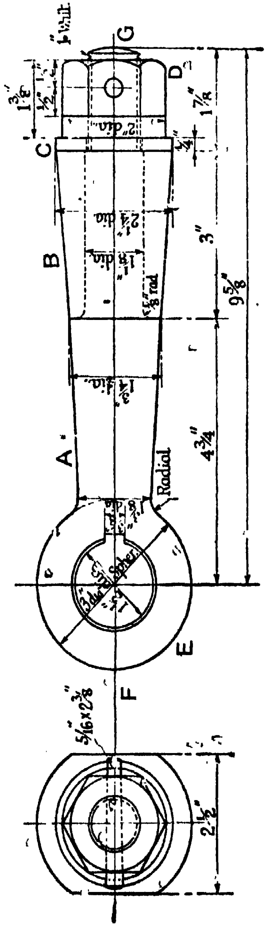

Fig 82

Picking-stud.—In those looms in which the motion of the shuttle is originated by an "overpick" motion, two wypers are fixed on the low or bottom shaft of the loom, one wyper near each end of the shaft. As the loom runs, the wyper bears against and pushes out a conical anti-friction roller running loosely on a stud bolted to or keyed on to the lower end of its upright picking-shaft. Fig. 82 gives two elevational views of the picking-stud in such looms, the type shown being that in which the stud is keyed to the shaft, and can therefore be adjusted, if desired, for vertical height. A is the stud proper, B is the conical anti-friction roller, C is a heavy mild-steel washer, while D is a large specially shaped nut, prevented from loosening by means of a standard taper pin driven through the nut and the screwed end of the stud.

Exercise 76.—Using the information given in fig. 82, make full-size detail drawings of each part in the picking-stud assembly shown.

Exercise 77.—Use the details shown in Exercise 76 to build up two complete assembly views of the picking-stud similar to those shown in fig. 82.

Exercise 78.—From the front elevational view drawn in Exercise 77 project a plan view.

Exercise 79.—Make a sectional plan, projected from the front elevational view drawn in Exercise 78, and taken along the centre line FG, fig. 82.

This example presents two or three points of minor interest. The taper pin shown is made in standard sizes, and is regularly used for fastening together any two parts which are not conveniently held by any other means. The diameter given is always that at the large end, and a common taper is 1 in 48 or ¼ in. per foot. Each end should be rounded off with a radius approximately equal to the diameter of the pin at that particular end.

It will be noticed that the diameter of the boss E, through which the hole for the picking-shaft is made, is dimensioned "3 in. dia. spher." (spherical), denoting that the boss is really a portion of a sphere. The spherical shape would, of course, have been placed beyond doubt had a plan been drawn, but the addition of the adjective "spherical" (abbreviated to spher.) renders such a view unnecessary.

It should be kept in mind that it is occasionally necessary to specify which is the deep end of the keyway. In the present case this is unnecessary, unless for any particular reason the large diameter of the taper pin were required to be in a definite relation to the deep end of the keyway.

The conical roller B (picking-cone) is of chilled cast-iron, i.e. moulded in metal in place of the usual sand. This method has the effect of cooling the molten cast-iron more rapidly than when cooled in a sand mould, and produces a very hard surface, able to withstand much wearing action. No special provision is made for lubricating this conical roller when it rotates on the stud, as it is usually a loose and easy fit, and oil can get in from the outside in sufficient quantity. The nut D is specially large and heavy, and in this case is of cast iron in place of the more usual mild steel. The other two parts, the stud proper and the washer, are of mild steel; the former is a forging, and the latter is machined from round bright bar.

PRINTED AND BOUND IN GREAT BRITAIN
BY BLACKIE & SON, LTD., GLASGOW.